THE DEVELOPMENT OF A FORECASTING METHOD FOR MINING HOUSE CAPITAL PROJECTS

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I, George Michalakis, submit this thesis for the degree of Master of Science in Engineering. I claim that this is my original work and that it has not been submitted in this or in a similar form for a degree at any University.

ABSTRACT

A broad description of a project is a single, non-repetitive enterprise which is undertaken to achieve planned results within a time limit and a cost budget. This description could equally well apply to fixing a punctured tyre, expanding an existing mine, the design of a computer system or the building of the pyramids. Modern civilisation is largely based on the successful completion of projects. It is surprising therefore, that it is only in the very *recent* future, since the 1950's say, that the effective management of projects has been considered worthy of academic attention. Today project management in in the process of becoming a management science in its own right.

This need for the effective management of projects is further evidenced **by** the emergence in large organisations of departments whose function it is to control projects. Typically, a project control department would, in addition to other functions, be required to report to management regularly on the health of a project - is the project on schedule and on budget? If it is not, management clearly needs to be given an indication of where the project is heading.

A number of techniques are in common use which claim to 'forecast' the final cost and completion date of a project. These techniques include the S-curve in its many forms and Critical Path Networking, amongst others. On close analysis however, it soon becomes apparent that although these techniques offer a wealth of useful information regarding the present state of the project, and give a qualitative idea of the direction the project is heading in, they do not give any quantitative indication of the final cost and completion date of a project. In other words these techniques are control methods rather than forecasting methods. Most forecasting tends, in fact, to be done by an expert judgemental process which is highly subjective.

It was felt therefore that there was a need for the development of an objective forecasting method. An informal Industrial Opinion Survey was conducted which confirmed this belief. On the basis of this it was decided to attempt to develop an objective forecasting method and to determine whether it was more useful, reliable and accurate than existing subjective forecasts. An exhaustive Literature Survey was then carried out in an attempt to find past work in the field. It was found that most techniques in use were control techniques as described above, with the exception of the Resource Appraisement Model developed by Dr P.P. Pekar. **This** model (with three variations), provides a means of recalculating the complete project plan in terms of cost at each report period in the light of reported expenditures. However, the model assumes the same time phasing as the original project plan. In other words, it assumes that the project will end on schedule. This assumption limits considerably the practical use of the model.

As a result, the Resource Appraisement Model was refined and modified somewhat to include the forecasting of time as well as cost. This was done by relating the two parameters independently to percent physical completion. The resulting model, known as the Generalised Resource Appraisement Model (GRAM), was then tested using a computer program and a case study project. The results of this evaluation were then compared to the forecasts which had been produced by the existing subjective method for the case study project.

On the basis of this evaluation it was concluded that the GRAM was more accurate but as reliable as the existing method in forecasting final project cost. It was also found that the model was much quicker in informing management of general project trends (i.e. over or under budgeting).

It was found however, that the model was too sensitive to large periodical fluctuations in expenditure which were not necessarily true reflections of changes in trend. There is reason to believe that this characteristic may be overcome with relatively minor refinements to the model.

The objectives of the thesis were therefore attained adequately. Inevitably however there remains a great deal of work to be done before the technique could be used with confidence. Future work is indicated in **taking** the model less sensitive to large random fluctuations, and making the model a more flexible management tool by allowing the 'what if' type of investigation.

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GLOSSARY *

ADAPTIVE EXPONENTIAL SMOOTHING: An objective-naive forecasting method where the relative emphasis between recent and older historical data *may* be adapated according to the current state of the environment in which the forecast is being made.

CONTROL TECHNIQUE: A non-analytical or qualitative means of predicting the outcome of a project.

CASH FLOW: The sum of the invoices received in respect of the orders placed in respect of external commitments.

CAUSAL (forecasting methods): Those methods which use data concerning variables other than the variable being forecasted, and which may affect the dependent variable.

COST RATIO: The ratio of the actual manhours used to date to the product of the projected total hours required to complete the project and the planned % complete; a measure of how effectively money is being used.

CRASH A PROJECT: Complete the project in the shortest possible time irrespective of the costs incurred.

CRITICAL PATH METHOD: A networking technique used to control projects.

EARNED VALUE: The value, in base budget units, of the actual work performed, regardless of the actual costs incurred. Note that this is NOT the same as value of work done.

EFFICIENCY RATIO: *The* ratio of % value of work done to % erection manhours used.

Underlined words are defined in this glossary.

ERECTION MANHOUR: The number of manhours expended during erection, building or construction of a project.

EXPONENTIAL SMOOTHING: An objective-naive forecasting method which places more emphasis on recent historical data than on older data.

EXTERNAL COMMITMENTS: The orders placed for materials or services with suppliers and contractors.

EXTERNAL EXPENDITURE: See "Cash flow".

FORECASTING TECHNIQUE: An analytical means of predicting the outcome of a project quantitatively.

GRAM: The Generalised Resource Appraisement Model.

MANPOWER: The manpower resource within the Company that is allocated to the project, normally expressed in Manhours.

MOVING AVERAGES: An objective-naive forecasting method in which all the data being used is given an equal weighting.

NAIVE: (forecasting methods) Those methods which use data concerning only the dependent variable, i.e. the variable being forecasted.

PPC: Physical Percent Completion.

PRODUCTIVITY: The ratio between the output of a project's resources in real measurable terms in creating economic value and the input of a finite resource such *as* manhours. This is normally epxressed as

$$\text{Productivity} = \frac{\text{Earned Value}}{\text{Actual Cost of Work Peformed}}$$

PRODUCTIVITY RATIO:	The ratio of Cumulative to Average Unit Rate.
PROJECT OUTCOME:	See "Outcome of Project".
OBJECTIVE: (forecasting methods)	Those methods where the process used to arrive at the forecast is well specified.
OUTCOME OF PROJECT:	The final cost, and date of completion of a project.
QUADPLOT IV:	A graphical Project Control Technique.
RESOURCE APPRAISEMENT MODELS (RAM)•	Adaptive exponential smoothing models which adjust the proposed project plan in the light of reported data.
SCHEDULE RATIO:	The ratio of the physical % complete to the planned % complete.
SMOOTHING CONSTANT:	The constant, a, which determines the relative weighting given to recent historical data compared to older data; it is used in exponential smoothing.
SUBJECTIVE: (forecasting methods)	Those methods in which the process used to obtain the forecast is not well specified.
UNIT RATE:	The Value of Work done per erection manhour.
VALUE OF WORK DONE:	The design and such other Head Office costs as are incurred, together with the value of all the materials delivered to and work done on site.

PREFACE

This Thesis consists of three main sections, namely the main body, the Theoretical Appendices and the Data or Case Study Appendices.

For ease of reference the main body is separated from the Theoretical Appendices by a blue divider, whilst the Theoretical Appendices are separated from the Case Study Appendices by a yellow divider.

CHAPTER ONE

INTRODUCTION

A project may be broadly described as "a single, non-repetitive enterprise" which is "undertaken to achieve planned results within a time limit and a cost budget" (1)

Failure to achieve the targets (i.e. the planned results within a time limit and a cost budget) can have serious consequences for the economic well-being of an organisation. A budget overrun means that additional funds have to be sought, more often than not at the eleventh hour, and at unfavourable terms. A budget underrun carries with it the opportunity loss of having committed sums of money which could have been utilised more profitably elsewhere. And at the end of the project it may even become apparent that a more profitable project could have been opted for at the evaluation stage when a number of potential projects were being considered. Furthermore, failure to complete the project within the planned time limit carries a heavy opportunity cost penalty, emphasising the dictum that "time is money".

In addition to these general problems, a mining project has a number of unique difficulties to contend with. In the first place even the most definitive capital estimates, and the most thorough engineering design and planning, cannot take into consideration complications introduced by unforseen mining problems (such as difficult rock conditions), and inaccurate estimates of the ore body which is present. Secondly, the Mining Industry in general has to contend with notoriously unstable market conditions.

The need to control a project effectively can therefore be seen to be of critical importance to the economic health of an organisation. The complexity of modern projects coupled with the immense sums of money involved (these two factors are not necessarily dependent) have fostered the emergence within large organisations of Project Control Departments (with an accompanying multitude of names). Their function has been variously described as

"* the systematic review and interpretation of project definition and execution from a cost point of view and prompt notification to the project manager of any deviations from the Control Estimate.
* knowing where you've been, where you are, and where you're going, and promptly telling the people who need to know" [2]. It should be pointed out, that the above descriptions apply equally well to time as to cost.

In order to achieve this function, the following duties are required from the Control Department:

"* Prepare all estimates.
* Receive (or have available) all appropriate documentation.
* Maintain Cost and Progress records.
* Maintain trend records.
* Analyse all information to reveal problem areas at the earliest possible time, and provide accurate and timely forecasts.
* Prepare periodic status reports of past and future project costs and performance" [3]

The quality of these status reports can therefore be seen to bear a central role in enabling management to make good decisions; poor monitoring will result in poor reporting, which in turn can mislead management to make poor decisions.

A typical report would indicate to management how much money has been spent on the project, how much money has been committed, how much money was budgeted and how much money it is forecasted that the project will cost. In addition, management would be told what the percentage completion and what the forecasted completion dates are. This information can be conveyed using tables or graphically, and could be divided by area, department or any other means suitable to the organisation.

The most contentious pieces of information mentioned above are the forecasts of final cost and date of completion. These are normally arrived at through an expert—judgemental process which is highly subjective: the Project Controller uses the information at his or her disposal to deduce the project outcome which seems most probable. This forecasting procedure is more of an art than a science and is dependant on the ability, know how, and experience of the forecaster. Indeed, "the conditions of an engineering project are so unpredictable and variable that very few forecasts can claim a high degree of reliability" (4)

These forecasts are manipulated and presented to management in a form which they then use to judge in what direction the project is heading. A number of manipulation techniques are in common use. They include the use of computerised networks, the S¯curve with its numerous refinements, monitoring productivity ratios and various other indicators, and a graphical technique known as Quadplot IV. However, these techniques are all constructed manually, they rely heavily on the compiler's abilities, they are not readily adaptable for use on computer, most treat time and money separately, and do not take into account any statistical trends in the project's history. Further, although these methods give an indication of the present state or health of the project, and may give some idea of where the project is heading they do not give a quantitative estimate of the project's duration or final cost, which is based on previous trends. In short, they are Control Techniques and not Forecasting Techniques as they are commonly referred to. As far as can be ascertained there is only one analytical technique which statistically accounts for historical trends. This technique monitors the variance between reported and planned quantities, and using adaptive exponential smoothing, forecasts the future project costs- It is known as a Resource Appraisement Model.

The objective of this Thesis therefore, is to refine the Resource Appraisement Model, and to generalise it by including the forecasting of time. This generalised model is then to be tested on a case study project, and compared to the existing subjective forecasting methods in order to determine whether or not it is more accurate and more reliable than existing methods. It should be emphasised that the intention of such a forecasting method is on reliable prediction rather than careful after the fact accounting.

CHAPTER TWO

LITERATURE SURVEY

2.1 INTRODUCTION

In any discussion of the forecasting techniques used in Project Control, it soon becomes apparent that there exists a certain amount of confusion as to the distinction between forecasting techniques and control techniques. For the purposes of this thesis, the term "forecast" will be used to describe any technique which analytically arrives at a quantitative estimate of the project outcomes in terms of cost and time. Those techniques which describe the current state of a project and indicate the future direction qualitatively will be referred to as control techniques. It should be noted that a forecasting technqiue as defined above may be used as a control technique as well. The converse however, is not true. This distinction will be used to classify the techniques currently in common use.

A number of further introductory comments may be made at this stage.

Figure 2-1 illustrates conceptually how the ability to control a project and the ability to accurately predict or forecast the project outcome vary during the project life-cycle.

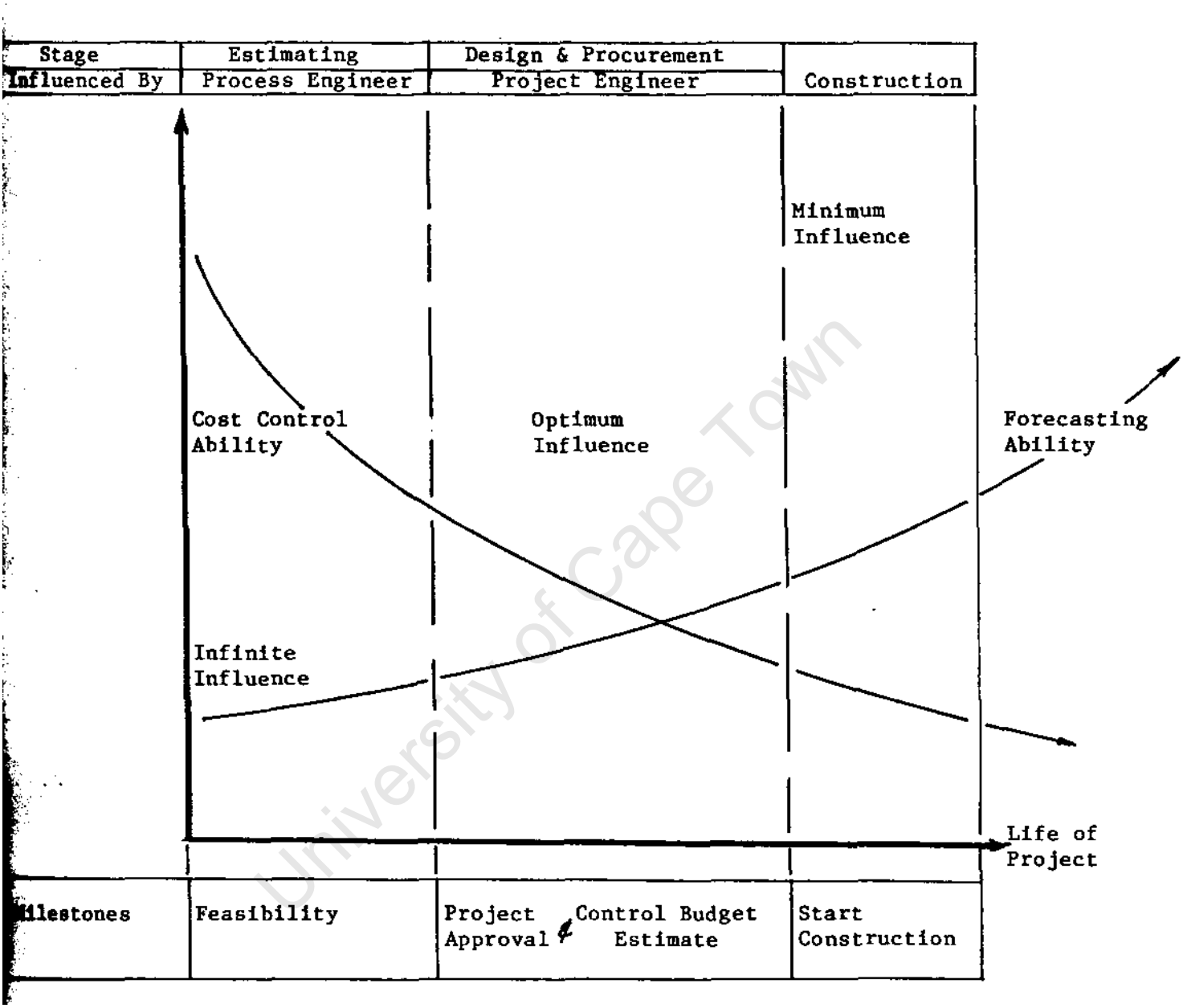

FIGURE 2-1 : COST CONTROL POTENTIAL

It can be seen that ideally the scope of the project *and* the design should be defined accurately as early as possible. Although this may be possible in most industries (Civil, Electric Power Generation) this is not the case with Mining projects. Design changes are often instituted once construction is well underway. The reasons are complex and include the fluctuations in product prices, escalation, revision of ore deposit estimates, unpredictable mining conditions and other problems.

This is therefore one instance where a solution has to be found without dealing with the complex causes of the problem. This solution is in having a system that can rapidly inform management of the potential consequences of their actions and highlight well before a critical situation develops any looming crises. It can therefore be seen that an approximate but reliable warning given *early* enough to initiate action is worth a lot more than an accurate or exact prediction given later when it is too late to act on the information. Referring once again to figure 2-1, it is apparent that when a great deal of information is available and the accuracy of forecasts is high, their use to management is limited. Hence, the emphasis in this field of forecasting is by necessity one of compromising between accuracy and usefulness to management.

2.2 CONTROL TECHNIQUES

2.2.1 The S-Curve

For the purpose of controlling a project there are four parameters which can be readily monitored. These are:

a) Manpower : the manpower resource within the Company that is allocated to the project. Although it is normally expressed in manhours it ultimately becomes a cost. This parameter has the advantage that it is normally immediately determinable.

b) External Commitments : the orders placed for materials or services with suppliers and contractors.

c) Cash Flow : the sum of the invoices received in respect of the orders placed under (b) above (5)

d) Value of Work Done : the design and such other Head Office costs as are incurred, together with the value of all the materials delivered to and work done on site (6)•

The relative importance of these four parameters changes during the life of the project. At the beginning and ending of the project's life, the external commitments provide a useful record, whilst it is the cash flow which is most important once the project is complete and provides the final cost (7)
Value of work done is the most useful indicator of project progress. However, the method by which it is determined should be standardised so as to avoid ambiguity.

When the above parameters are plotted on a scale of time, a characteristic curve results, usually referred to as the "S-Curve" because of its shape. This is illustrated in figure 2-2.

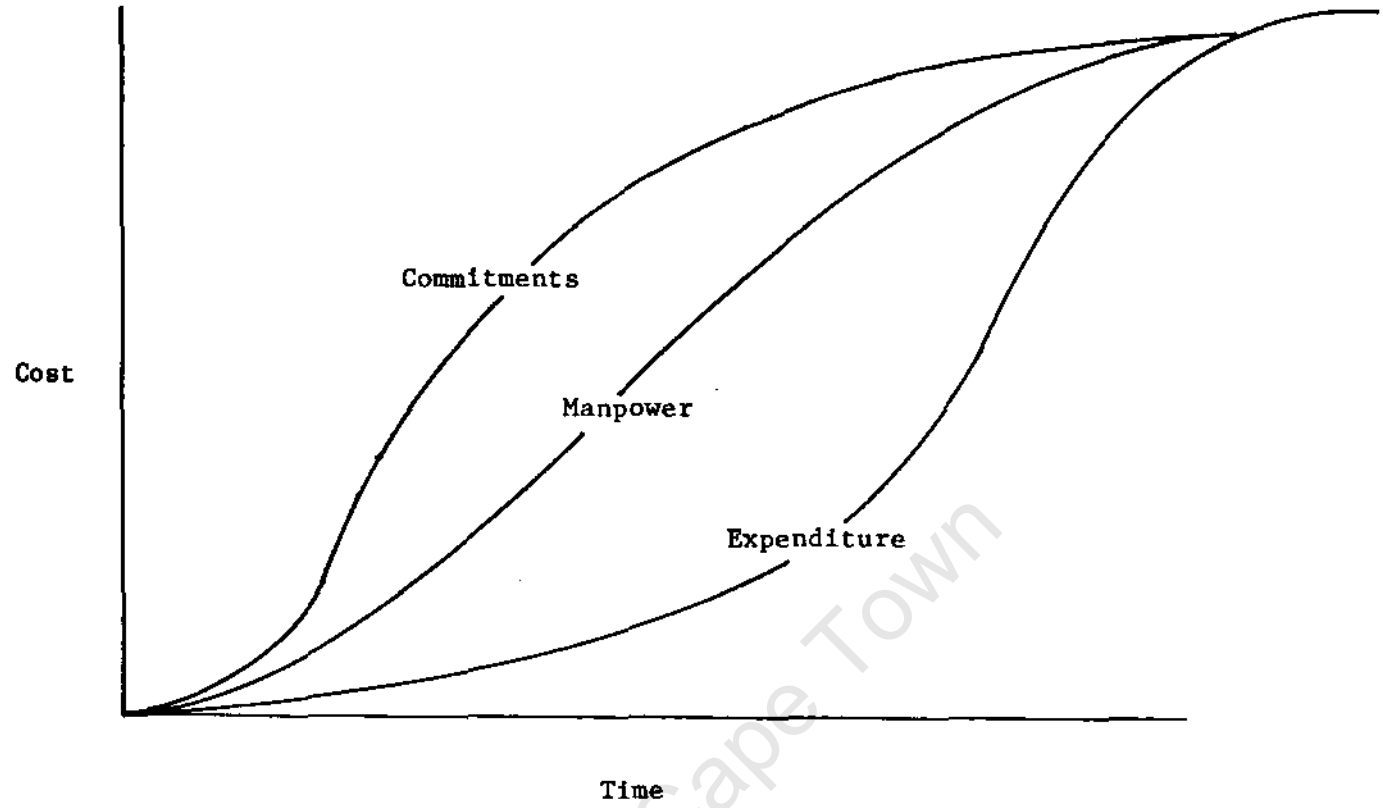

FIGURE 2-2 : THE CHARACTERISTIC S-CURVES([6])

The characteristics of S-Curves are well documented (8 - 11 inclusive) For any particular area of capital investment, and for a particular project development and management approach, the S-Curve is essentially *always* the *same* when drawn in normalised units, i.e. % complete, % of total time, % of total cost, etc. (9)

This fact is what makes the S-Curve such a useful control tool. In fact, "radically different types of installations can well have a different S-Curve, but the difference will never be signficant. The margin of error in this statement is never more than +- 10% and within these limits it can be taken as a law" (9)

In its simplest form the S-Curve may be used to determine how the project is faring compared to what was planned and scheduled. This is done by plotting a succession of points on the curve and comparing the present position to what was planned, as shown in figure 2-3.

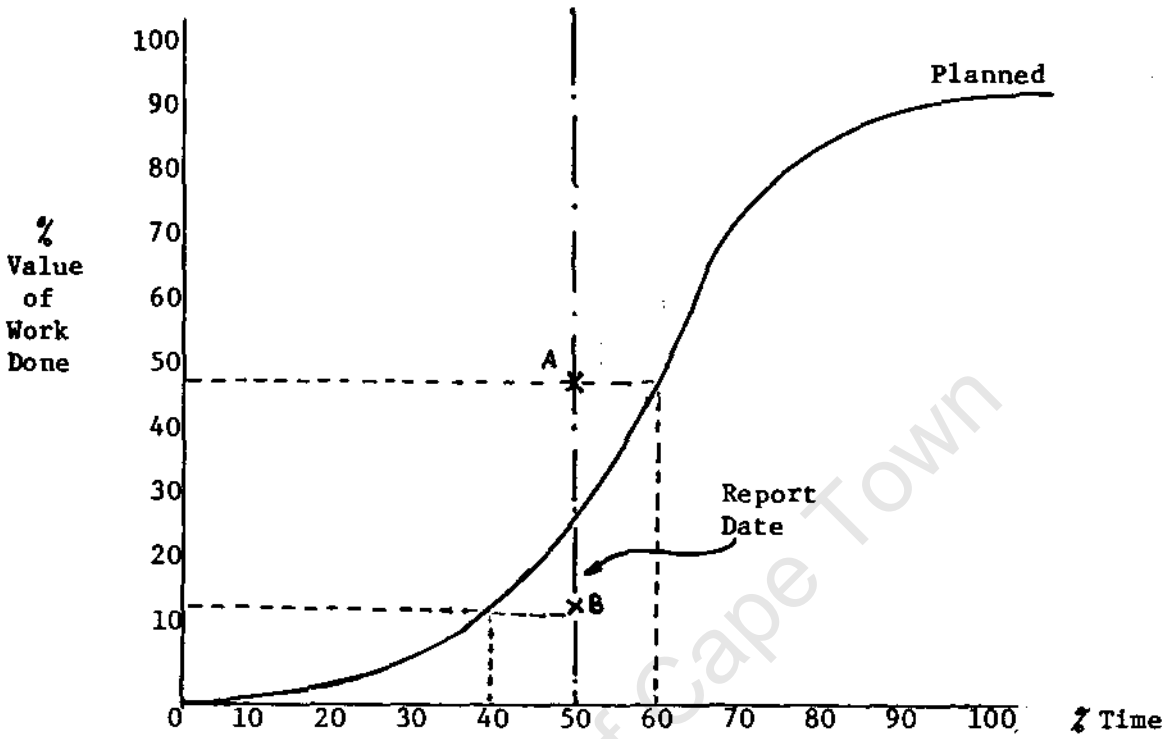

FIGURE 2-3 : USE OF S-CURVE TO CONTROL THE PROJECT

In figure 2-3, point A would indicate that the project was ahead of schedule by 10% compared to the planned progress, whilst point B would indicate that the project was behind schedule by 10%. It should be noted that this does not tell us what the final outcome of the project will be. It merely gives us an indication of how the project is as of the report date. It is also worth pointing out that the curve in figure 2-3 could have been plotted with any of the four parameters described in the above discussion, depending on what information was required at that point in the project's life.

2.2.1.1 Network Derived S-Curve: This form of the S-Curve is constructed from a Critical Path Network (see 2.2.3). The user is required to supply, for each activity, the cost associated with the activity. It is then possible to obtain the Planned Cost Curve shown in figure 2-4 below, where the curve indicates the cost if all the activities start early, late or on schedule (12)

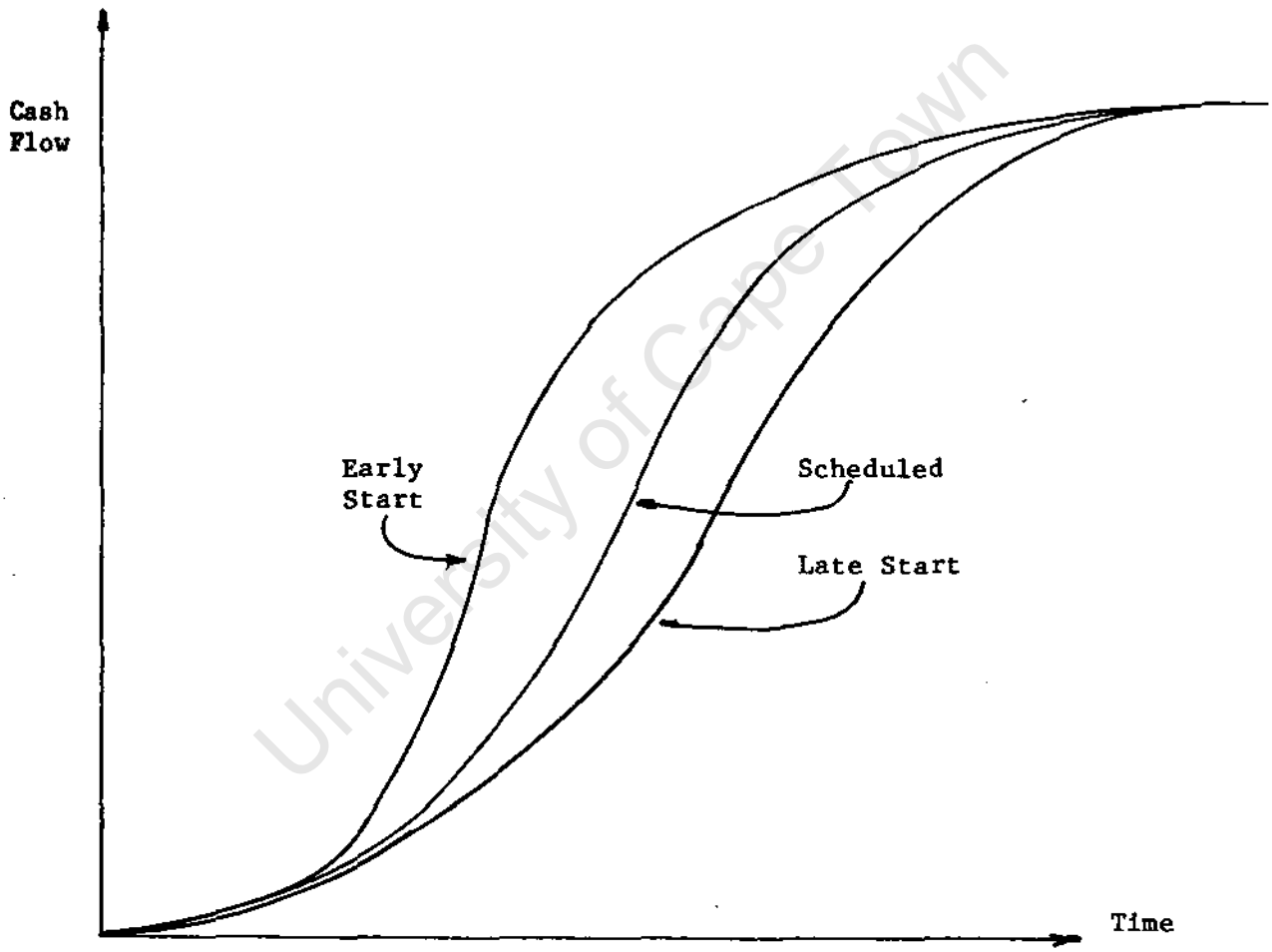

FIGURE 2-4 : NETWORK DERIVED S-CURVE(12)

This curve therfore gives the user some idea of the range in which the project can fall, based on the network logic.

2.2.1.2 Probabilistic S-Curve: This form of the S-Curve may be constructed in a number of ways [11, 13]. The most recent technique [13], uses Monte Carlo Simulation and a Critical Path Network to determine the probabilistic curve shown in figure 2-5.

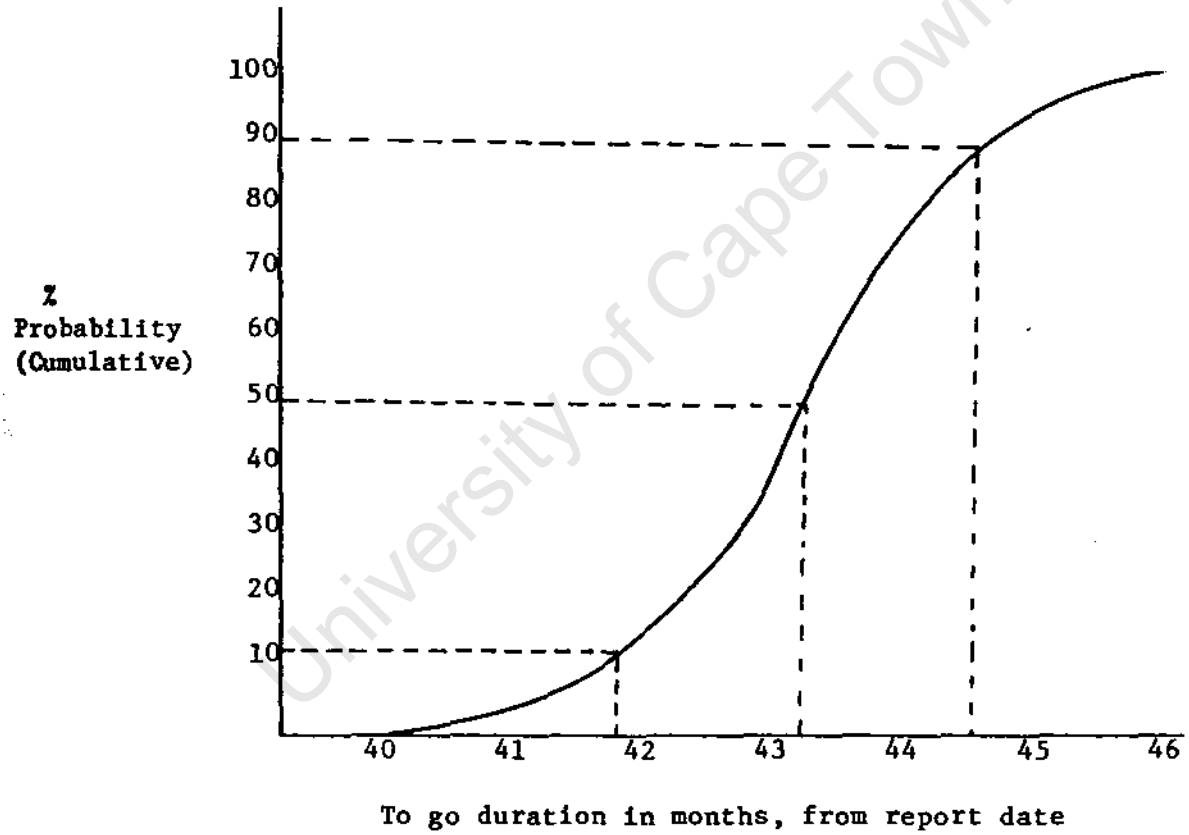

FIGURE 2-5 : PROBABILISTIC S-CURVE[13]

From this it is then possible to construct a so-called Banana Curve (shown in figure 2-6) which can be used to indicate the range of values within which the project can finish on schedule.

This form of the S-Curve is more realistic and useful than the Network Derived type of Curve. However, both techniques are limited in that they do not give a quantitative indication of what the project outcome will be.

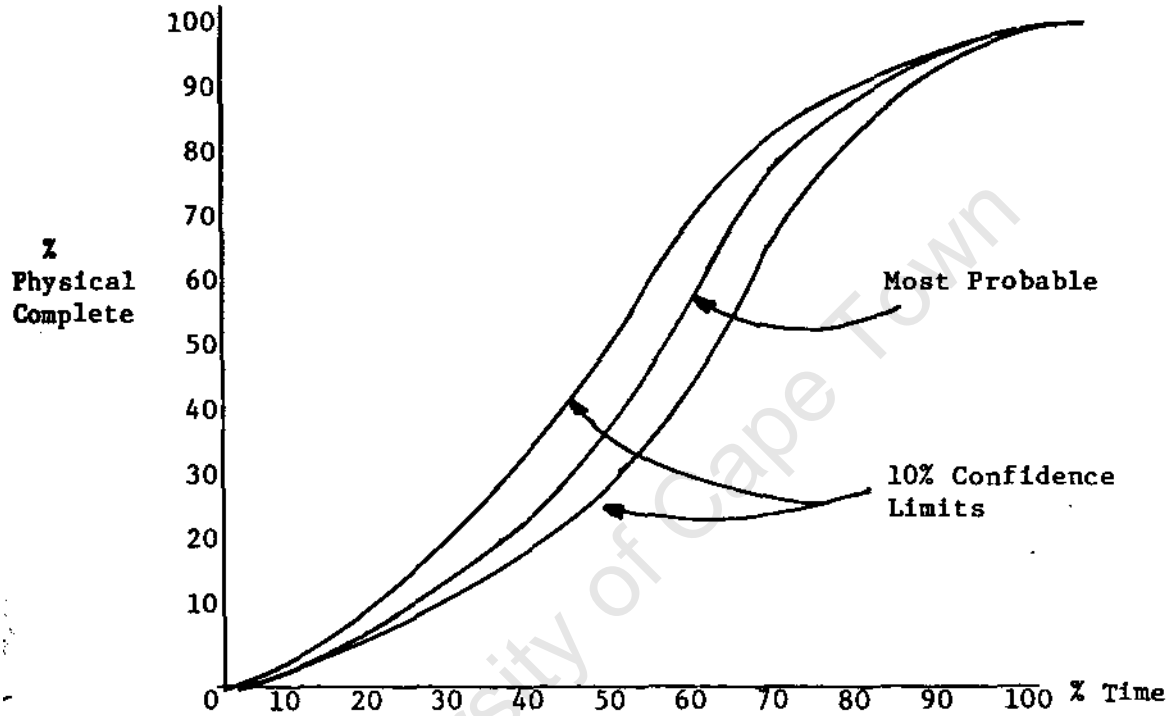

FIGURE 2-6 : BANANA CURVE

2.2.1.3 Use of the S-Curve: For any one project it is customary to maintain a number of S-Curves. Used in combination these curves can offer a wealth of information regarding the project. The curves normally used are:

a) External Commitments vs Time,
b) Cash flow vs Time,
c) Z Complete vs Time, and/or
d) Value of Work Done vs Time.

Figure 2-7 is a set of curves from a hypothetical project illustrating how these curves are used.

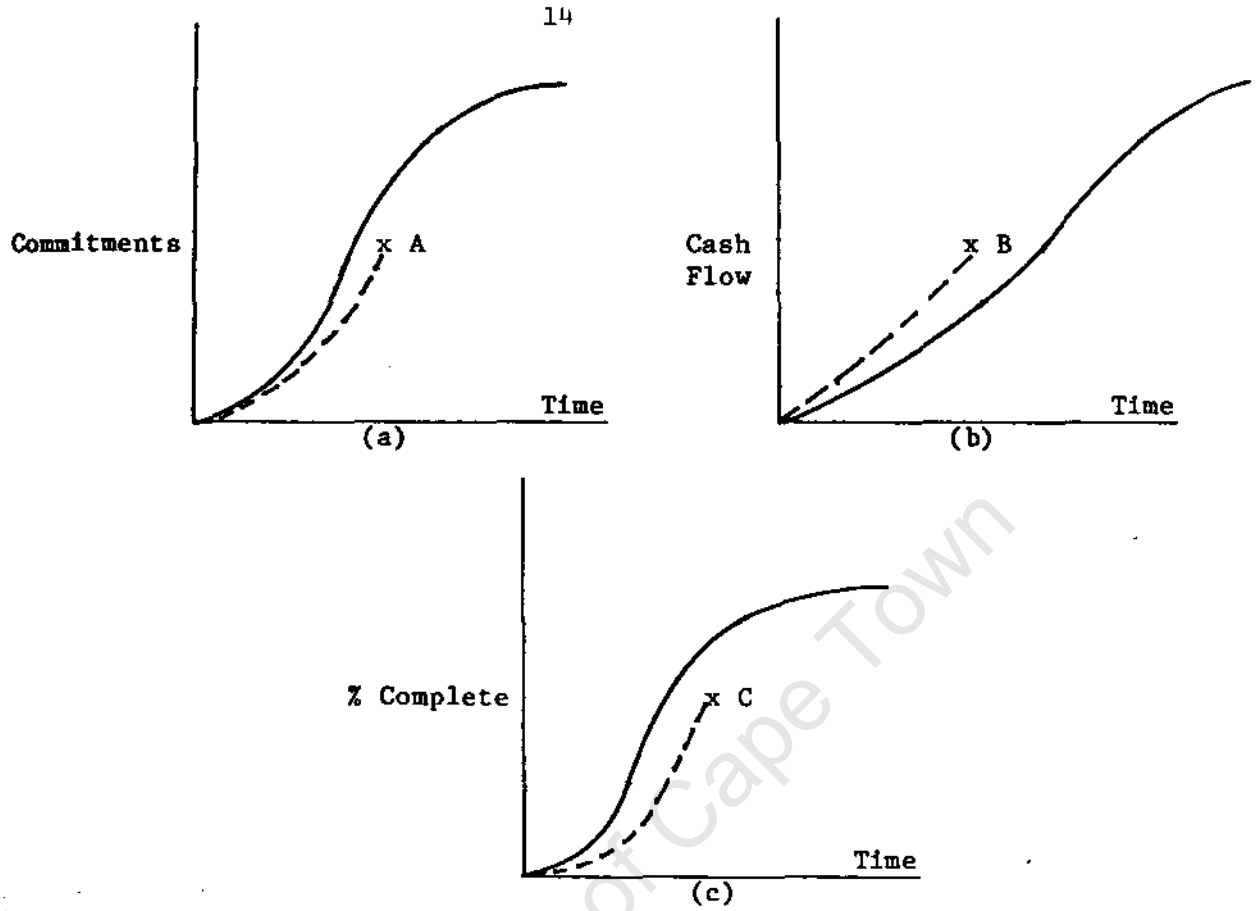

FIGURE 2-7 : S-CURVES FROM A HYPOTHETICAL PROJECT

Curve (a) indicates that commitments are not as high as was planned. On the other hand, the cash flow diagram, curve (b), indicates that the cash flow is higher than planned. This would imply that:

1) Orders are not being placed as rapidly *as* planned.

11) Money is being spent much faster than planned.

These two factors combined could mean that the original estimate was too low, or that the escalation is higher than was planned. The latter is supported by the fact that the 2 completion curve, (c), is behind schedule. Hence Management would now have to determine:

a) Why the orders/contracts are behind schedule, and

b) What is causing the high cash flow discrepancy.

Bearing in mind the above reasoning, the technique would give management some idea of what direction their investigation should be concentrated in.

Note however, that the technique has not given Management any idea of what the project outcome will be. Furthermore, because of the practical limitations of the scales used to construct the S-Curve, it is difficult to judge performance accurately.

2.2.2 Quadplot IV

In this graphical technique, a cost ratio and a schedule ratio are plotted at the end of *each* review or reporting period.

The ratios are determined as follows:

$$\text{Cost Ratio} = \frac{\text{Actual Manhours Used to Date}}{(\text{Projected Total Hours Required})\ (\text{Planned \% Complete})}$$

$$\text{Schedule Ratio} - \frac{\text{Physical \% Complete}}{\text{Planned \% Complete}}$$

The co-ordinates which are then plotted on the axes illustrated in figure 2-8, are determined as follows:

Cost Co-ordinate = 1 - Cost Ratio
Schedule Co-ordinate = 1 - Schedule Ratio

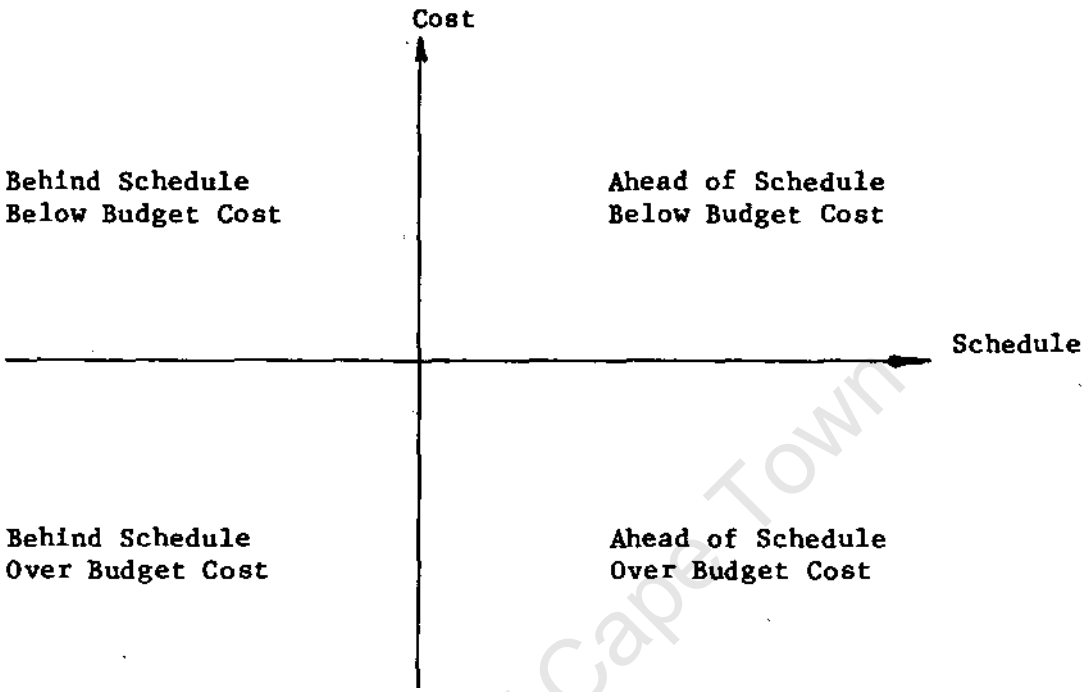

FIGURE 2-8 : QUADPLOT IV CO–ORDINATES ([14])

Target circles are drawn on the diagram at the end of *each* period to depict the *maximum* limit of prudent permissible deviation at that point in time[15]. If a co-ordinate falls outside this target circle, management is automatically given the warning that something may be amiss. The direction vector between two consecutive points on the diagram also gives an important indication of the state of the project (16)

Quadplot IV only points out the possible existence of a problem area. It must always be used with other monitoring systems (16) However, it does overcome the scaling problems of the S–Curve.

For a more detailed explanation of this technique, see (17)

2.2.3 Critical Path Method

This is one of the most commonly used project control techniques. A wealth of information is available and the reader is therefore referred to [18, 19]. What follows is merely a discussion of the technique.

Computers have made this technique extremely versatile. (See 2.2.1.1) However, problems exist in using Critical Path Methods [20] The salient points are as follows:

a) Although most computer packages have costing facilities (21) they are not yet sophisticated enough to integrate the control of time and cost. This is in fact a problem common to most techniques. The actual problem would appear to be organisational as it is traditional to keep control of time and money separate.

b) The technique is very suited to initial planning and scheduling, the setting of milestone dates and obtaining a global view of the project. However, "whilst remarkable advancement has been achieved in the area of networking techniques and sophisticated reporting, the rating of sucessful utilisation of such systems has not attained a comparable growth" (22)

c) Assuming that the computer facilities to manipulate a large (4 000 plus activities) network are available, the cost and effort required to maintain a network is often prohibitive.

d) It is not a forecasting technique in the sense described in section 2.1. It relies on the user to supply the information for each activity.

e) People's reaction to a computer printout needs to be considered, as well as "The Computer Says So" Syndrome.

It would appear therefore, that "the project Network method is the most powerful technique yet developed for planning and scheduling a project. But, it has not proved as useful for monitoring and controlling a project' (22)

2.2.4 Productivity

A number of systems exist which claim to be capable of effecting project control by monitoring labour productivity during the life of a project. In this section the method advocated by Huot[23] is described. In the next section Stallworthy's method is dealt with, this being a method using a combination of indicators.

Huot[24] defines productivity as the ratio between the output in real measurable terms in creating economic value and an input of a finite resource such as manhours:

$$\text{Productivity} \quad \frac{\text{Economic Value}}{\text{Labour Cost}}$$

In terms of measurable performance it is then possible to express productivity as the ratio between the earned value and the actual labour input for the work performed:

$$\text{Productivity} = \frac{\text{Earned Value}}{\text{Actual Cost of Work Performed}}$$

Where earned value is the budgeted cost of the work which has been performed.

These values are readily available from an S–Curve of the kind illustrated in figure 2-9. Note that earned value and actual cost of work performed are usually expressed in either manhours or money. A project is considered to be productive if the above ratio is greater than unity.

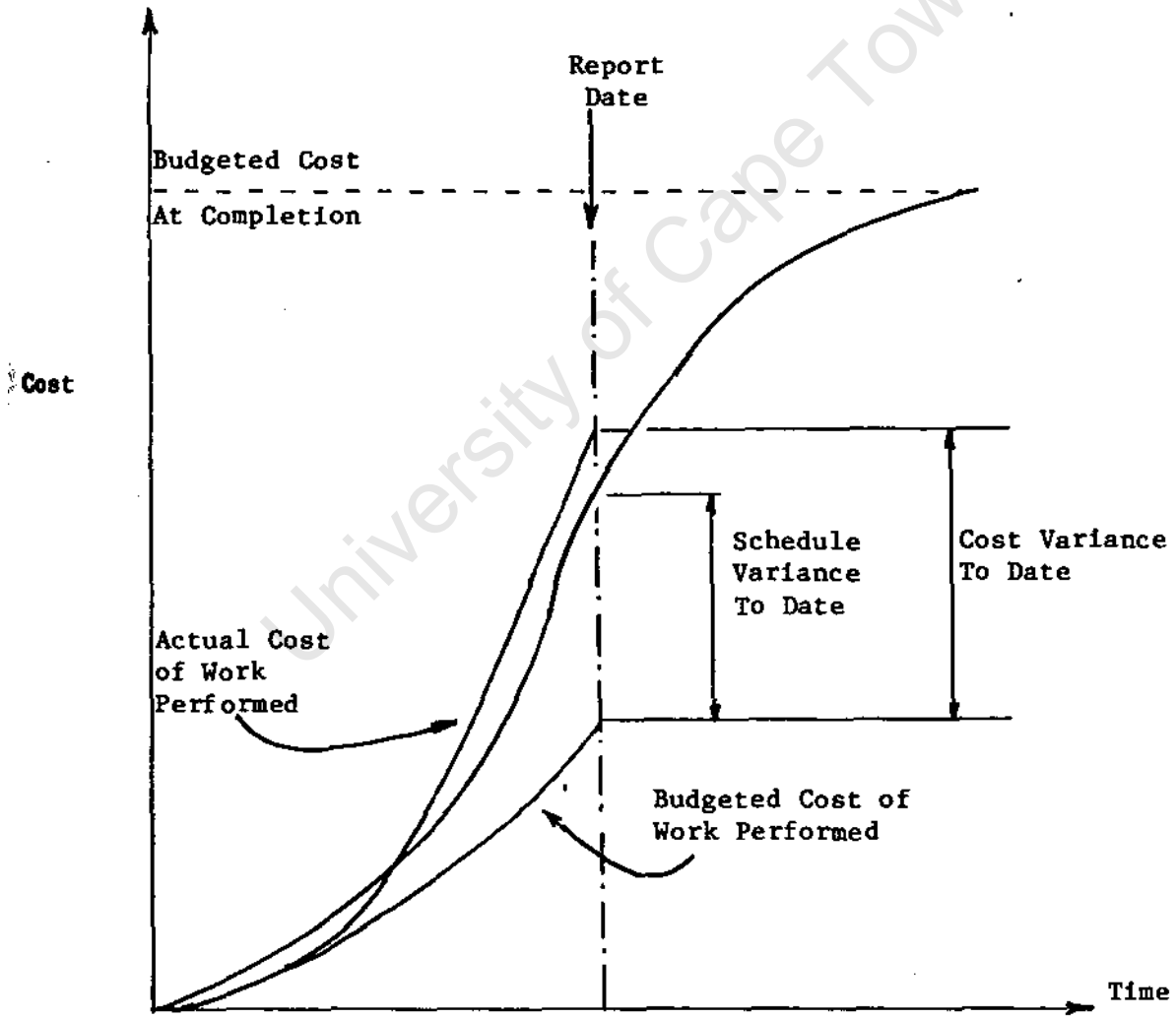

FIGURE 2-9 : THE PERFORMANCE MEASUREMENT SYSTEM(24)

It has been found empirically that a continuous plot of productivity vs % completion yields a characteristic curve as illustrated in figure 2-10.

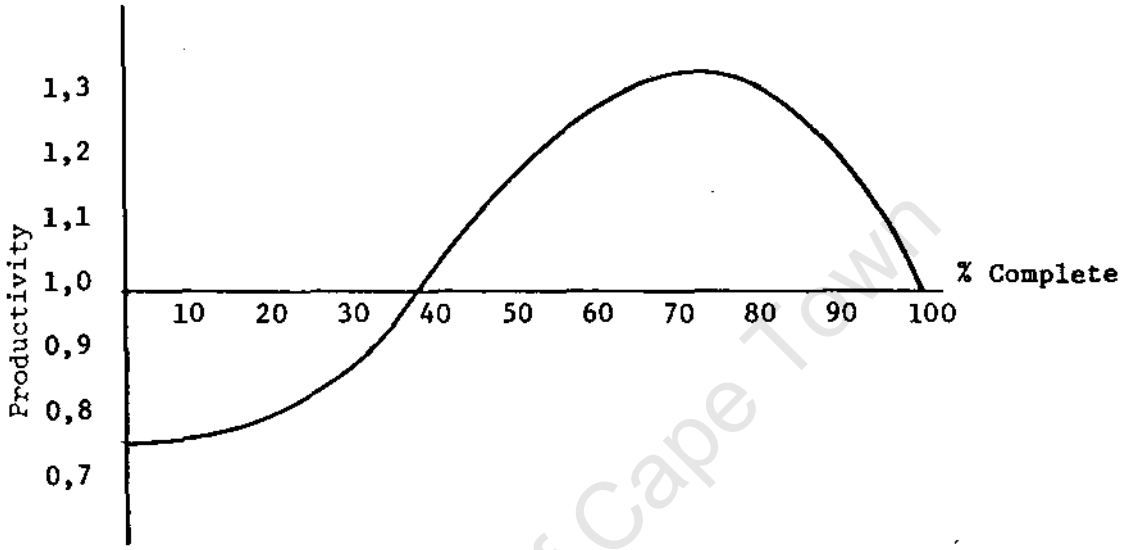

FIGURE 2-10 : THE PRODUCTIVITY PROFILE([24])

The shape may be intuitively explained as follows:[24]

At the beginning of the project productivity is below unity due to the mobilisation of the work force and the learning curve effect. However it increases steadily to a maximum and decreases towards the end of the project.

It is claimed[25] that it is possible to forecast the productivity at the end of the project using the following formula:

$$\text{Productivity at Completion} \quad \frac{\text{BCAC - BCNP}}{\text{FACC - ACWP}}$$

Where BCAC Budgeted Cost at Completion.
BCWP o Budgeted Cost of Work Performed.
FACC Forecasted Cost at Completion.
and ACWP = Actual Cost of Work Performed.

It is also possible to calculate the productivity required to complete within budget:

$$\text{Productivity required to complete within budget} = \frac{BCAC - BCWP}{BCAC - ACWP}$$

Hence by manipulating productivity, it is possible to "do more for less" and exercise effective project control.

The major stumbling block with this method is that it relies on an accurate forecast of the cost to completion. It therefore needs to be used in conjunction with a forecasting technique or one of the other control techniques described in this chapter.

Further, the formulas given above assume a linear relationship between cost and productivity. No published report of this could be found.

Finally, although with some refinement this technique could be used to exercise control, it may be seen that it is not a forecasting technique in the sense described in section 2.1.

2.2.5 Stallworthy's Empirical Control Method

A detailed explanation of this empirical technique is given (26). What follows is a brief description.

Three curves need to be plotted in this method. The first is a value of work done vs time S-Curve as discussed in section 2.2.1. The second curve plots the productivity ratio (not to be confused with "Productivity" as defined in section 2.2.4) against value of work done and is illustrated in figure 2-11. The productivity ratio is defined as the ratio between the cumulative and average unit rates where the unit rate is the value of work done per erection manhour, i.e.

$$\text{Unit Rate} = \frac{\text{Value of Work Done}}{\text{Erection Manhours}}$$

and

$$\text{Productivity Ratio} = \frac{\text{Cumulative Unit } \textit{Rate}}{\text{Average Unit } \textit{Rate}}$$

The third curve plots the efficiency ratio against % of project duration, where

$$\text{Efficiency Ratio} \quad \frac{\text{\% Value of Work Done}}{\text{Erection Manhours}}$$

This curve is illustrated in figure 2-13.

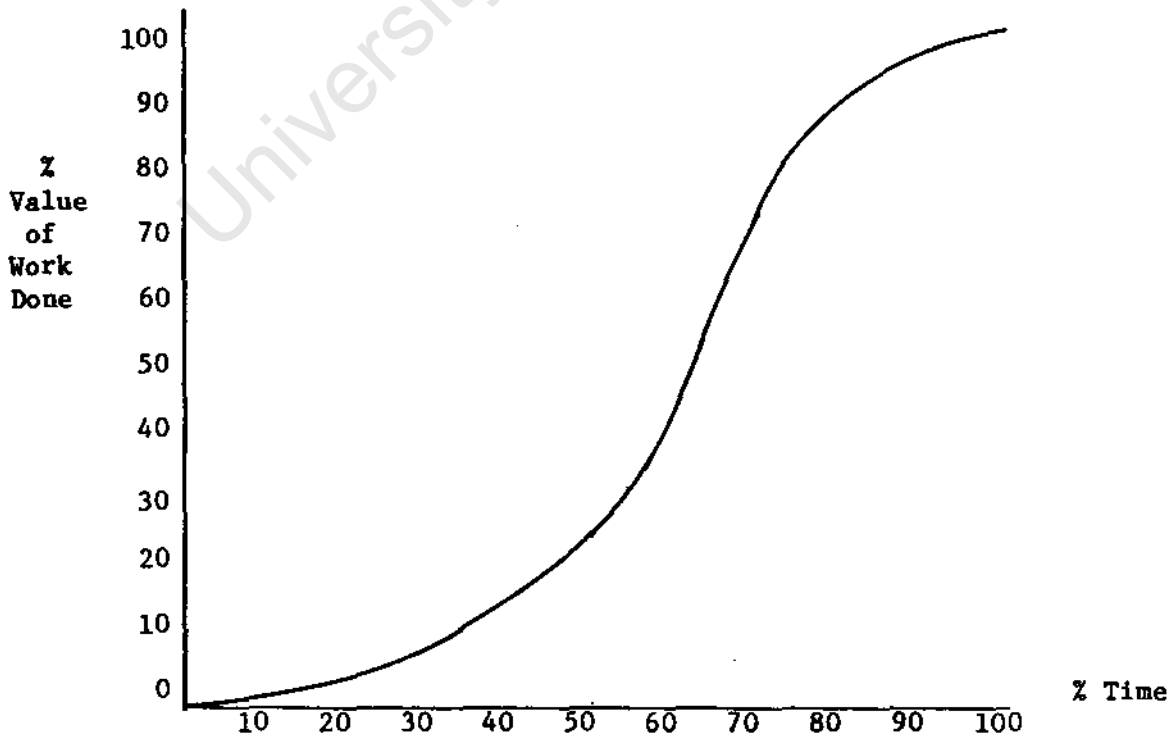

FIGURE 2-11 : S-CURVE FOR VALUE OF WORK DONE(27)

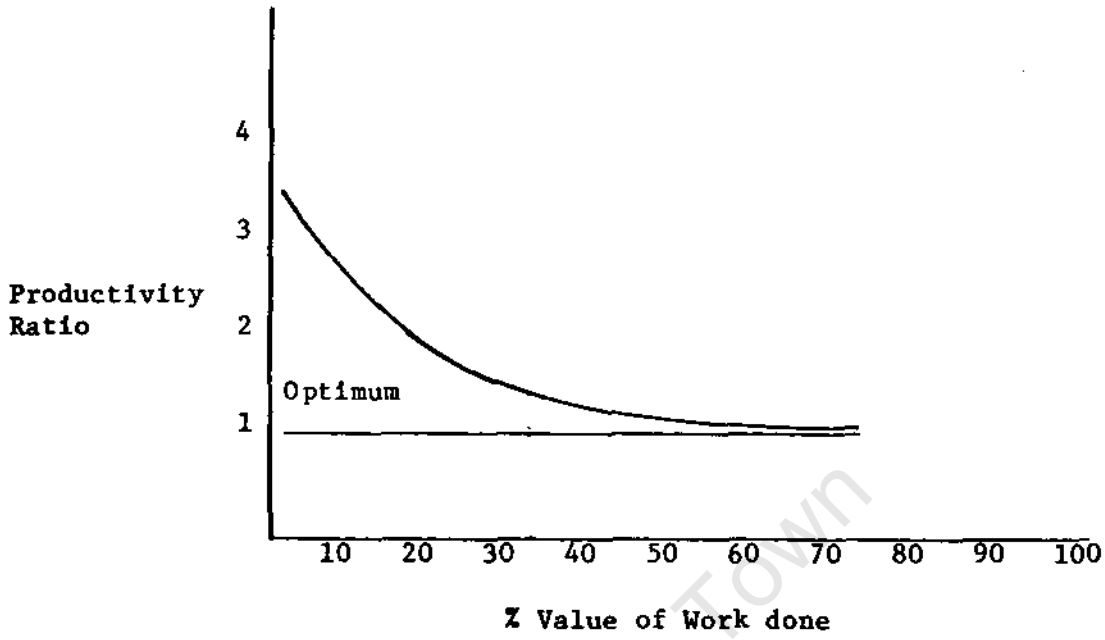

FIGURE 2-12 : PRODUCTIVITY RATIO VS VALUE OF WORK DONE([28])

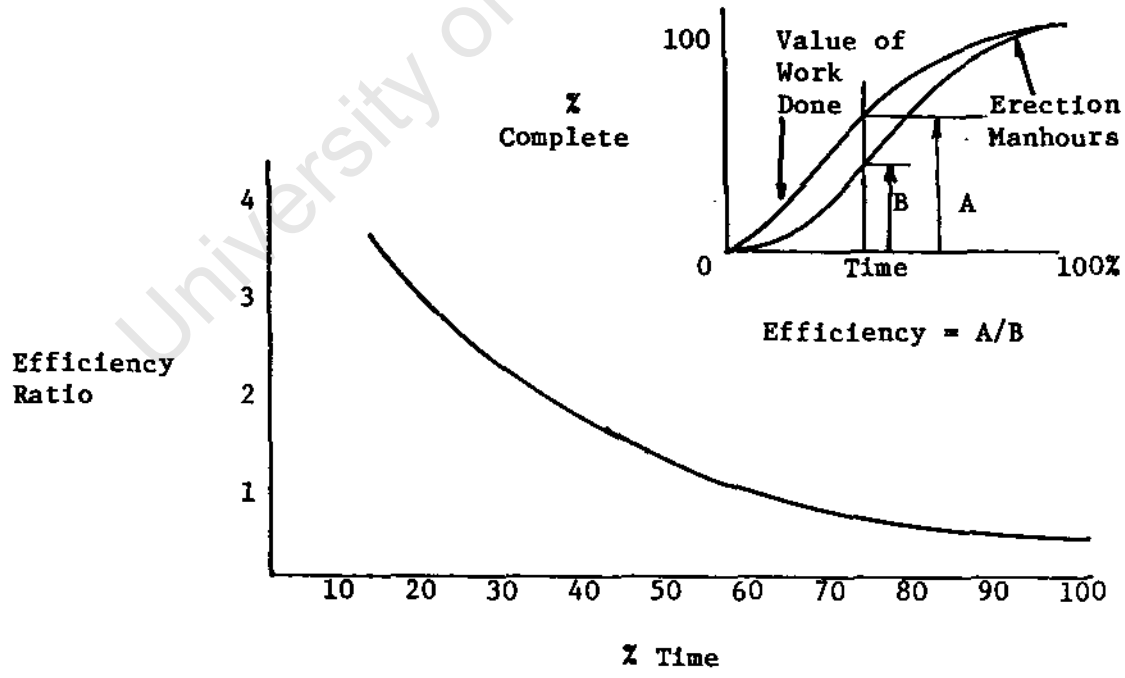

FIGURE 2-13 : EFFICIENCY RATIO VS PROJECT DURATION(29)

The use of this technique is best demonstrated by the example in Appendix C-1 (adapted from [30]).

The following comments may be made concerning this technique:

a) It considers both time and money as well as productivity and efficiency;

b) It uses easily available information (the curves may be constructed from the planned parameters of the project);

c) The technique is manual and not easily adapted for use on computer.

d) The technique itself is based on intuitive rather than logical assumptions and reasoning, although the curves appear to be based on empirical facts.

2.3 FORECASTING TECHNIQUES

2.3.1 Introductory Literature Survey

A brief Introduction to Forecasting is warranted before considering the Resource Appraisement Models.

Armstrong and Grohman[31] introduce a useful concept for describing the field of forecasting. They use two dimensions to classify the various techniques: the first dimension deals with the method used to analyse the data and is called the subjective–objective dimension; the second deals with the type of information used and is called the naive–causal dimension. This is illustrated in figure 2-14. They then go on to define the dimensions as follows:

Objective	Extrapolation	Econometrics
Subjective	Novice Judgement	Expert Judgement
	Naive	Causal

FIGURE 2-14 : FORECASTING METHOD DIMENSIONS ([32])

SUBJECTIVE (also known as judgemental, intuitive, implicit) methods are those in which the process used to obtain the forecast is not well specified and is carried out in the forecaster's mind.
OBJECTIVE methods are those where the method used to arrive at the forecast is well specified, and two different people can come up with (nearly) identical results.
NAIVE methods are those which use data concerning only a dependent variable.
CAUSAL methods also take into consideration other variables which may affect the dependent variable.

These two dimensions give rise to four general classifications of forecasting methods:
SUBJECTIVE-NAIVE referred to as novice judegement, which is basically the same as uninformed guessing and is not dealt with any further;
OBJECTIVE-NAIVE which refers to extrapolation techniques and includes least squares extrapolation and time-series analysis;
SUBJECTIVE-CAUSAL which is referred to as an expert judgemental method where an expert uses information at his or her disposal to deduce the forecast; and
OBJECTIVE-CAUSAL which refers to econometric techniques and includes regression analysis.
A number of studies have been carried out comparing these methods.

Armstrong and Grohman tested the following hypotheses using airline passenger data (32):
HI Objective methods lead to more accurate long-range market forecasts than do subjective methods.
H2 Objective methods tend to be relatively more accurate than subjective methods as the change in the environment increases.

H3 Causal methods lead to more accurate long—range market forecasts than do naive methods.

H4 Causal methods tend to be relatively more accurate than naive methods as the change in the environment increases.

"Change in the environment" was measured by the length of the forecast horizon, the implication being that as the time span increases, there is a greater likelihood that large changes will occur in the environment. They concluded that within certain confidence limits, and taking cognisance of conflicting results from other studies [33, 34], their hypotheses were all validated.

Hogarth and Makridakis [35] qualitatively evaluated forecasting and planning with a view to assessing forecasting accuracy and planning effectiveness in organisations to provide guidelines to calibrate expectations. This they did by reviewing findings from psychology concerning human judgement, assessing current approaches to forecasting and planning, and proposing alternative conceptualisations. They reported [36] that it was a well accepted fact that humans have a limited ability to process information but that we have a strong motivation to understand and thus control the environment in which we live.

They cite numerous studies which have compared the predictive performance of experts to that of simple quantitative models and conclude that the models generally perform in a superior manner (37) (Some of these studies are described below). They stress that "Planning cannot assume forecast accuracy .... one should use forecasts, but not <u>believe</u> in them [38]. They also suggest that since people are inefficient at aggregating information, this should be done mechanically [39]

Mabert[40] compared a number of statistical techniques to forecasts obtained from the expert judgemental process. His conclusions were that whereas the judgemental process is capable of anticipating changes in trends, the statistical methods are much quicker to use, require fewer manhours and are generally more accurate (41)

Elton and Gruber[42] compared the accuracy of forecasts of earnings per share for a number of companies obtained using various mechanical (extrapolation) methods to those from experienced stock brokers. Their conclusions were that exponential smoothing methods on average performed best across a large sample of firms (43)

Kahneman and Tversky[44] propose a system by which forecasts made by the expert judgemental process may be adjusted for bias. They found two major types of bias, namely non-regressiveness of predictions and overconfidence. They attribute these to people's tendency to give insufficient emphasis to certain types of information. Their corrective procedures aim to elicit from the expert relevant information which would ordinarily be neglected, and assist in integrating this information with intuitions in a manner which is compatible with the basic principles of statistics (45)

Chambers, Mullick and Smith,[46] in their qualitative appraisal of forecasting methods, identify time series analysis as a methodology which produces acceptable short-term forecasts routinely at low cost.

The above would indicate that in general one should attempt to use Causal-Objective models, i.e. econometrics. In the field of project planning however this is a neglected aspect, probably because the factors influencing a project are so numerous and complex. The emphasis has till now been on subjective techniques. It is therefore worthwhile to look at naive objective techniques in more detail.

2.3.2 Introductory Theory and Literature Survey to Adaptive Smoothing Models

Time Series Analysis refers to those forecasting techniques which analyse the past history of a dependent variable to predict the future of that same variable. One specific kind of time series analysis is the use of moving averages[47] Moving averages, as the name implies, average the dependent variable for the previous n time periods (n is generally between 3 and 7 time periods) and uses this average as a prediction of the dependent variable for one time period into the future. The main shortfall of this method is the fact that it gives an equal weighting to all the data available. The effect of this is illustrated in figure 2-15 (which was constructed using hypothetical data) where the 4 month moving average provides a reasonable forecast for the stable periods but lags far behind actual demand as soon as a step change in demand occurs (such an effect could be the result of an advertising campaign or a new product launch, amongst others).

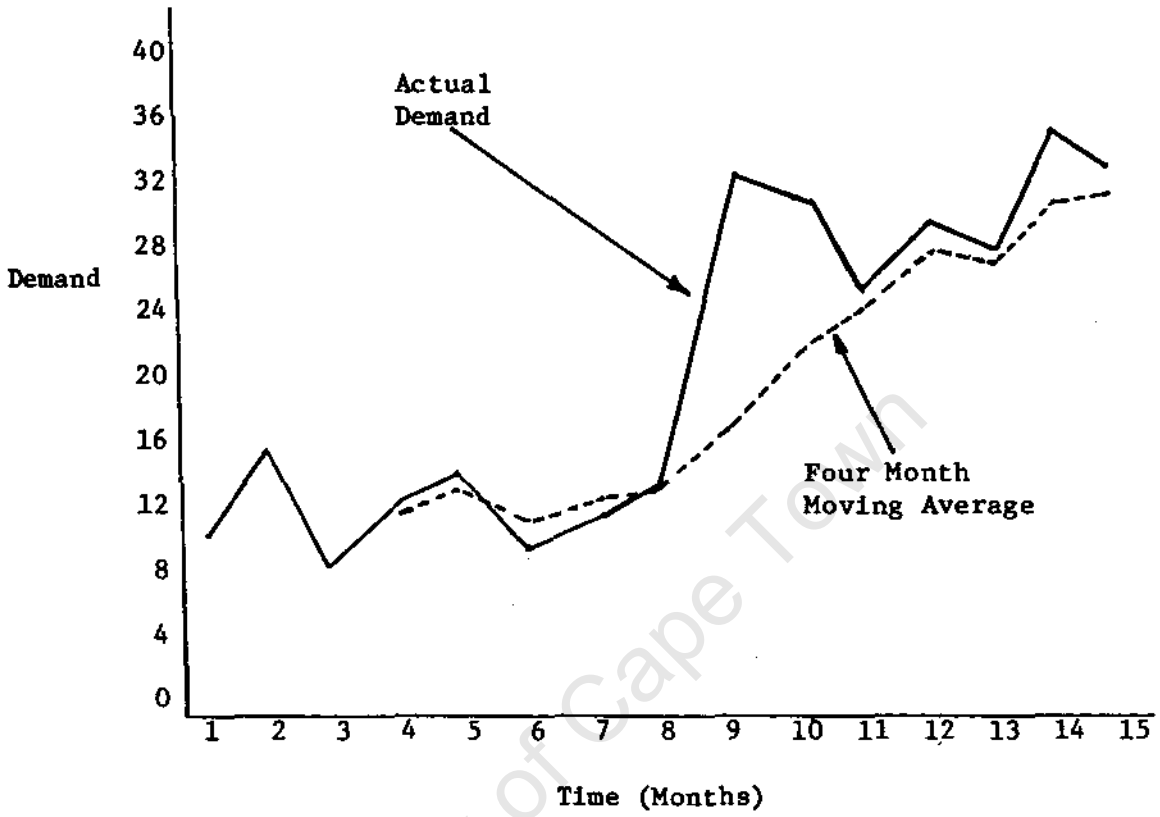

FIGURE 2-15 : FOUR MONTH MOVING AVERAGE

In general

$$D_t = \frac{d_t + d_{t-1} \; d_{t-N+1}}{N}$$

is the actual average of the N most recent observations computed at time period t, where D_t is the average and d_t is the actual demand at period t. According to this model, D_t is the forecast for the next period.

The improvement on this method is the exponential moving average or exponential smoothing method as it is more commonly known. In this technique the most recent data is given a higher weighting than the older data (for a formal derivation see Brown (48) and Winters (59)). In its simplest form the model assumes a demand in any period expressed as

$$d_t = D + e_t$$

Where: d_t = demand in period t
D = mean demand level
e_t = random fluctuation normally distributed about the mean demand.

The exponential smoothing equation is then

$$S_t = a\, d_t + (1 - a)\, S_{t-1}$$

Where: S_t = Smoothed demand in period t (which is an estimate of D);

and a - Smoothing constant (O.< a 4.1)

The forecast of the demand per period, using this model is simply S_t. A smoothing constant between 0,1 and 0,2 has been found to provide good, stable forecasts in practice (49) This relatively low range of values for the smoothing constant enables the model to smooth out random fluctuations and produce values of S_t that closely approximate the demand, D.

However, when the demand mean, D, is subject to change (for the same reasons enumerated above) the smoothing effect becomes a liability. Under these conditions a low value of the smoothing constant, a, means that the forecasts will react slowly to a demand shift, and could be over or under the new mean demand for some length of time. On the other hand, a smoothing constant value close to one, has the advantage of decreasing the length of time during which the model's forecasts differ greatly from the new mean demand, but does not provide much smoothing of the randomness when the demand is stable. The solution to this dilemma has been to devise means for providing low values of a, the smoothing constant, during stable demand periods, and high values when the mean demand shifts. Such models are known as Adaptive Smoothing Models.

Whybark[50] classifies the various approaches developed for adapting the smoothing constant by use of two dimensions. The first dimension is that of the frequency with which the smoothing constant is evaluated. Some models evaluate the constant only after a specified number of periods of operation, called the evaluation interval. The performance of the model over all those periods is used to determine whether a different value of the smoothing constant should be used for the next set of periods. Other models change the smoothing constant every period if the evaluation of the model's performance indicates that a change is warranted (continuous evaluation).

The second dimension is defined by the method used to determine the smoothing constant. Some models use prespecified values of the smoothing constant or restrict the amount of change that can be made (constrained choice). Other models compute the value of the smoothing constant, or leave the choice unrestrained (unconstrained choice). This provides a total of four combinations as illustrated in figure 2-16.

	Periodic Evaluation	Continuous Evaluation
Constrained or prespecified choice of smoothing constant	Roberts and Reed([52])	Whybark(53)
Unconstrained or computed value of smoothing constant	Eilon and Elmaleh([54])	Trigg and Leach([55])

FIGURE 2-16 : CLASSIFICATION OF ADAPTIVE SMOOTHING MODELS([51])

Whybark[(56)] compared the four models using an inventory system. His conclusions were that the continuous' evaluation models exhibited slightly better performance than the periodic evaluation models when compared on the basis of the standard deviation of the errors. The constrained (Whybark) model was slightly better at smoothing random fluctuations during stable demand as compared to the unconstrained (Trigg and Leach) model. When the four models were compared on the basis of computer time and storage capacity required, the continuous evaluation models were favoured.

It should be noted that the Exponential Smoothing Model is readily developed to include trend and seasonal terms. (See Winters [(59)]).

More recently, Berry and Bliemel (60) have used pattern search techniques to choose the smoothing constant. They compared the results of this method to those obtained by Winters[61] using a grid search, and concluded that pattern search reduced the computing time considerably, but did not necessarily find the optimum value of the smoothing constant. They recommend that the two methods should be used in combination as pattern search is a lot faster. Once a preliminary solution has been determined, the grid search would then be used to optimise the solution.

Kirby[62] compared Exponential Smoothing Models to moving average models and concluded that exponential smoothing provides superior performance for medium—range forecasts.

Dancer and Gray (63) compared a simple exponential smoothing model to an adaptive one and concluded that there was no statistically significant difference in the performance of the two models. However, they recommend that adaptive models should be used on the basis of their reduction of manual intervention and lower information storage requirements.

2.3.3 Resource Appraisement Models

Pekar (64) found that none of the techniques described above were directly suitable to determine the outcome of a project: "Since project plans may take any variety of function contours, and since mathematics have not developed, as of yet, a general procedure to match these infinite patterns with specific functional equations, new techniques had to be developed to simulate these contours".[65]

He called these techniques "Resource Appraisement Models" (RAM). They differ significantly from previous models in that:

i) they are created from piecewise linear segments that are able to match any contour;

ii) the smoothing constant is a function of the uncertainty and complexity measures (associated with the contours) and not the forecasting error,

iii) the deviations between the planned contours and the actual ones are used to predict turning points in the project plan and not the smoothing constant.

Pekar developed three models which he refers to as RAM I, RAM II and RAM III. RAM I provides a means of recomputing the complete project plan in terms of cost at each reporting period in the light of the reported data using the same time phasing of project events as the original plan The technique therefore anticipates the future level of spending and does so with increasing confidence as each month's data is added to the data base. The emphasis is on reliable prediction of costs rather than careful after the fact accounting. If the predicted deviations for the whole plan are large enough to cause significant impact on the overall project program, then the project is further reviewed using RAM II and RAM III.

RAM II adjusts the proposed project plan in the light of reported data, but keeps the total cost to the budgeted limit (constrained) If it transpires that this is not possible (due for example to practical cashflow limits), RAM III is then used to adjust the project plan with the minimum of modifications possible (flexible constraint).

Detailed derivations are reproduced in an adapted form in Appendix D for all three models, and includes examples of how they are used.

2.4 DISCUSSION

Current literature seems to imply that forecasting bias should be towards the use of objective as opposed to subjective techniques as these are generally more reliable. In the field of project control such techniques have only been developed by Pekar. In evaluating the Resource Appraisement Models, it is clear that although they are sophisticated mathematically, their application is relatively straightforward and well suited for use on computer. Some general comments[67] are:

* The predictive capabilities of the method are easily used by management for project cost control.
* RAM always relates to the original project plan which it then modifies in the light of reported data. However RAM is also capable of indicating when the original plans have lost their relevance to actual performance and hence when a project review is called for.
* RAM provides warning of potential project overruns at an early enough stage for management to be able to act.
* RAM is adaptable as an interactive system for budget sensivity analysis.
* In its present form RAM only considers the cost dimension and ignores time completely. This is a major weakness of the technique if compared to the Control Techniques.

It is therefore apparent that there exists a need in this field for a naive objective technique which accounts for both time and cost.

An informal survey was conducted within General Mining Union Corporation and amongst other companies (see Appendix E for a brief qualitative description). The general consensus was that such a technique would be of value to the companies and persons concerned, provided it complemented rather than replaced the existing subjective techniques.

CHAPTER THREE

THE DEVELOPMENT OF A GENERALISED RESOURCE APPRAISEMENT MODEL

3.1 INTRODUCTION

Chapter Two described the forecasting techniques and methods in current use in the field of Project Control. It was shown that the major problem associated with Control Techniques is the fact that they do not provide a quantitative indication of the project outcome despite offering a wealth of useful information of the state of the project. The only Forecasting Technique which attempts to overcome this problem is the Resource Appraisement Model developed by Pekar.

In this Chapter Pekar's RAM is qualitatively evaluated, and a number of shortcomings are discussed. A discussion then follows which proposes solutions to these shortcomings. Finally a number of criteria by which the effectiveness of the Generalised Resource Appraisement Model may be evaluated are discussed. A quantitative justification of GRAM is given in Appendix F.

3.2 A QUALITATIVE EVALUATION OF RAM

In this section the Resource Appraisement Model is discussed and evaluated qualitatively. This is done by considering in turn the model's shortcomings.

3.2.1 Forecasting the Completion Date

The Resource Appraisement Model (RAM) discussed in Chapter Two and Appendix D assumes that a project will *always* end on schedule. Using this fixed time scale, it forecasts the expenditures for each ordered time period of a project by monitoring the variance between the forecasted expenditures and the expenditures reported in a time period.

The assumption of a fixed time scale places an undesirable constraint on the model. In general management wishes to know if the project will indeed end on schedule. In some cases it may be desirable to investigate the expenditures which would be required to achieve an on—schedule completion, but this is a special case, rather than the general state of affairs.

It can therefore be seen that any forecasting model should forecast both the completion date and the final cost of a project. It should however be sufficiently flexible to allow management intervention should it be necessary to investigate the cashflow which would result if the project were to be 'crashed' (i.e. finished in the shortest possible time irrespective of the cost), or finished by some other target *date.*

3.2.2 Nature of Forecasts

The exponential smoothing method is, as discussed in Chapter Two, an objective naive forecasting method. This implies that forecasts are made with no consideration of the factors affecting a time series. In applying the method to Project Control however, and in attempting to evaluate RAM, some discussion of casual factors is warranted.

In most projects an estimate is made of the project cashflow which eventually becomes the voted budget. A number of factors can affect the variance between a budget and the actual expenditures. These include the optimism or pessimism of the group making the estimate, price escalation other than inflation (inflation is normally forecasted within acceptable limits), changes in the original project scope, and unforseen problems in executing the project. A naive forecasting method implicitly assumes that any variance during the project execution resulting from the above factors will prevail for the whole project. Although this may be true when accounting for estimating optimism or pessimism, it is generally not true for the remainder of the factors. No study could be found which compared the relative effects of these factors on a project. For the purposes of this discussion however, it is assumed that estimating optimism or pessimism accounts for the greater proportion of the variances.

Accepting the above, it follows that the per unit or relative variances through the life of a project should be monitored and forecasted. This is not the case with RAM. The quantity being forecasted is not relative but absolute - the absolute change in gradient for any forecasting period. Referral to the RAM forecasting equations (See Appendix D, equations D-20, D-21 and D-22) shows that the expenditure gradient (i.e. rate of expenditure in terms of money per unit time) in an ordered time period, is forecasted by monitoring the error between what was forecasted in the previous time period and what was actually spent:

New gradient old gradient + constant (error in latest update gradient) 3-1

It can be seen from this equation that when the old gradient is small (i.e. a low rate of expenditure), and the error in the latest update is comparatively large (irrespective of the constant), it is possible to obtain a negative new gradient. This implies that the client is being paid by contractors to work for him - an enviable but unrealistic situation.

By monitoring the relative error this situation would not arise, since the new gradient would be a multiple or fraction of the old one, as the case may be. In other words the relative change would be forecasted and this would in turn be used to calculate the forecasted gradients.

3.2.3 Calculation of Smoothing Constant

The constant mentioned in equation 3-1 is in fact the smoothing constant referred to in Chapter Two. Referral to equation D-22 shows that the smoothing constant in any time period in RAM is in fact a weighted average of what Pekar refers to as the uncertainty associated with the rate of expenditure in that period, compared to the sum of all the uncertainties for the project. In words, equation D-22 could be rewritten as:

$$\text{Smoothing Factor for period j in the future} = \frac{\text{Uncertainty of Expenditure in period j}}{\text{Sum of all uncertainties from present update to completion of project}} \qquad 3\text{-}2$$

One measure of the uncertainty is the contingency associated with any time period. In most projects the contingencies are allocated as a fixed percentage of the total estimated cost (between 3 and 10% for most projects). It is therefore not very easy to find an objective measure of uncertainty which will differ from time period to time period. Consider therefore a project which is planned to be completed in twenty time periods (for argument's sake say months). Using equation 3-2, the smoothing constant for any time period will be given by

$$\text{Smoothing constant in period j} = \frac{\text{Uncertainty in period j}}{\text{Total project uncertainty}}$$

$$= \frac{\text{(P.U. contingencies) x (Planned expenditure in period j)}}{\text{(Outstanding project expenditure) x (P.U. contingencies)}}$$

$$= \frac{\text{Planned expenditure in period j}}{\text{Outstanding project expenditure}} \qquad 3\text{-}3$$

Now it is shown later in this Chapter that the periodical planned expenditures in a project resemble the well-known 'bath-tub' curve (this fact follows directly from the fact that time and cost have an S-curve relationship).

It can therefore be seen that the above formula for the smoothing constant will have a relatively higher smoothing constant at the start and end of a project. In most projects these are actually the stages where the planning is at its most reliable (at the start of the project the design is more or less complete for the initial phases of the project and hence the planning and estimating is more reliable; at the end of the project the final touches are being put to the project and these are not of critical importance in most cases) and hence where one would require relatively smaller smoothing constants. The periods at which most of the work is done and hence where more can go wrong are the ones in the middle stages of a project (the steep area on an S-curve). This is the part of a project which requires more sensitive monitoring and hence, intuitively, relatively larger smoothing constants.

It can therefore be seen that the smoothing constants used in RAM are the opposite of what is intuitively required of a smoothing constant in such an application.

There is however a further disadvantage associated with equation 3-3. The nature of the smoothing constant was discussed in Chapter Two. It determines the rate at which the forecast can adapt to large changes in the forecasted time series. A smoothing constant of zero makes the forecasted parameter equal to the previous forecast whilst if it is unity it puts the forecast equal to the most recent reported value - it determines the relative weighting given to recent as opposed to older update data.

It can be seen from equation 3-3 that the smoothing constant can never equal unity unless the project consists of one time period. Indeed the value of the smoothing constant decreases, on average, hyperbolically as the number of time periods is increased. This is an undesirable characteristic since in practice most projects consist of a great number of time periods.

The above discussion indicates the nature and failings of the smoothing constants used in RAM. It would appear that the conventional approach of making the smoothing constant dependent on the response rate required for a forecast is more suitable.

3.2.4 Summary of Evaluation of RAM

To summarise the discussion of this section, the following refinements of RAM seem to be desirable. (These refinements serve as a set of requirements for the Generalised Resource Appraisement Model discussed in the next section):

a) The forecasting model should forecast the duration as well as total cost of a project.

b) These forecasts should be based on the exponential smoothing of the relative variance between the reported parameter (time or cost) and the value which was forecasted most recently.

c) The forecasting model should use a smoothing constant which is dependent on the response rate required from a forecast.

d) The forecasting model should be flexible enough to allow management to simulate the consequences of their actions (e.g. 'crashing' a project).

3.3 DEVELOPMENT OF A GENERALISED RESOURCE APPRAISMENT MODEL

The refinements of RAM proposed in section 3.2 are discussed in this section. Each proposal is considered in turn and they are then integrated in section 3.3.5.

3.3.1 Integration of Time and Cost Forecasting

In attempting to integrate the forecasting of time and cost analytically one immediately faces the problem of relating time and money. No general mathematical formulation of this relationship is easily arrived at, since each project is unique. However, it is possible to empirically relate time to per cent physical completion (PPC), and, separately, cost to PPC. Using these empirical relations it is then possible to relate time to money.

This is a significant departure from normal practice since traditionally time has always been considered the base to which all other variables are related. In this case however, time is itself considered a dependent variable, since, within certain constraints, it is possible to vary a project's duration by varying the resources available to it. Figure 3-1 illustrates the relationship between Time and PPC which resembles the well-known bath-tub curve. This figure shows the progressive durations required to achieve a certain amount of progress in PPC. In other words, it is a histogram using very small intervals of PPC. It can be seen that before project construction can actually start, a comparatively long period of time is spent before any physical progress is accomplished. This period would include feasibility studies and initial design prior to commencement of construction. Once project construction is underway however, the amount of time required to achieve a certain PPC decreases and bottoms out when the organisation's resource limit is reached. It then gradually increases again as the project nears completion.

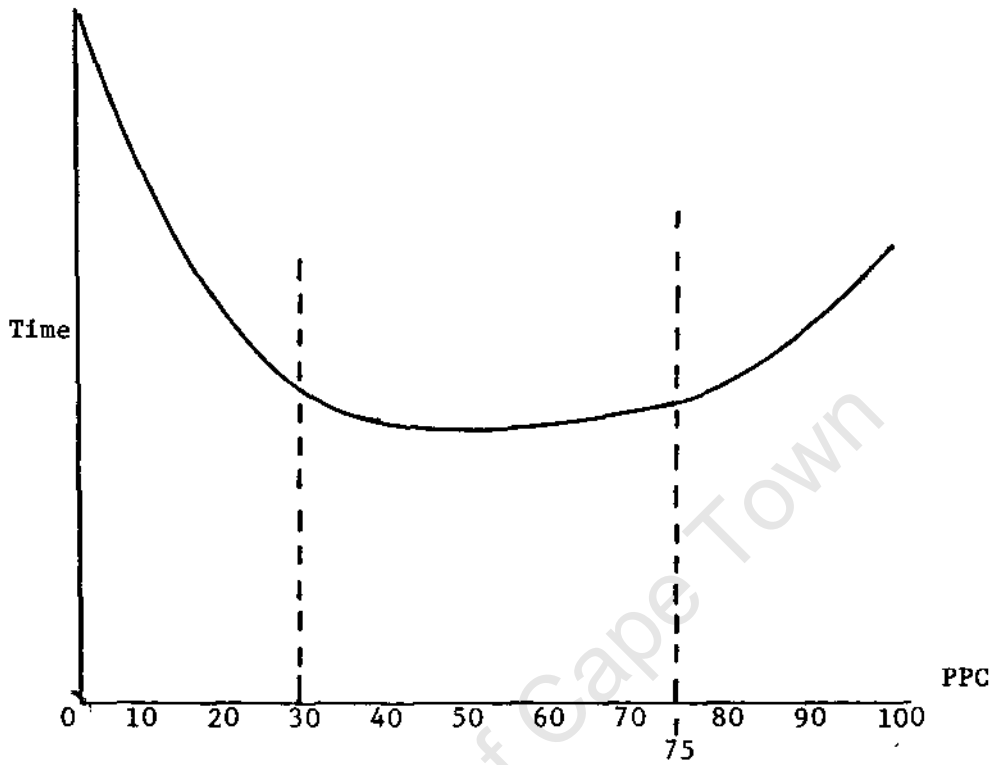

FIGURE 3-1 : TYPICAL TIME-PPC CURVE - the curve is a histogram using very small intervals of PPC

These observations are consistent with the familiar PPC vs Time S-curve described in Chapter 2.

A similar curve may be arrived at for cost: the amount of money required to achieve a certain PPC at the start of a project exceeds significantly that required to achieve the same amount of PPC during the rapid progress phase of the project.

By monitoring the variance between what was planned and what is being reported during a project it should be possible to forecast independently the duration and cost of a project. The two parameters could then be related through their common variable, PPC.

3.3.2 Forecasting Method

It was mentioned in section 3.2.4 that the Generalised Resource Appraisement Model (GRAM) should base the forecasts of time and cost on the relative variance between the reported parameter * and the value which was forecasted most recently. This implies that the new or forecasted parameters would be a simple multiple of the old parameter. The exponential smoothing method would be used to determine the value of this multiple which is referred to henceforth as the forecasted relative change in gradient. Furthermore it is assumed that this forecasted relative change in gradient is applicable to the remainder of the project. The forecast would be done independently for time and cost. Each would be related to PPC and a forecasted contour for each parameter versus PPC would be obtained.

Note that the original budget would need to be 'doctored' to obtain a Cost-PPC and Time-PPC relation as illustrated in figure 3-1. Further, unlike the fixed time intervals of RAM, the planned or ordered intervals of PPC will in general not coincide with the reported intervals of PPC, since these are normally determined at regular time intervals. It is for this reason that the gradients (cost per PPC and time per PPC) are considered rather than the actual parameter.

* the term 'parameter' is used here to denote the variables time and cost

The above may be summarised as follows for cost (the expressions for time are identical):

$$\text{Actual relative change in gradient} = \frac{\text{Actual expenditure since last update}}{\text{Forecasted expenditure for the same interval of PPC}} \quad 3\text{-}4$$

$$\text{Forecasted relative change in gradient} = \text{previous forecast} + k\,(\text{actual relative change in gradient} - \text{previous forecast}) \quad 3\text{-}5$$

Where It is a constant (the smoothing constant) for any update.

Using the forecasted relative change in gradient, the forecasted gradients are then calculated as

$$\text{Forecasted gradient} = (\text{old gradient}).(\text{forecasted relative change in gradient}) \quad 3\text{-}6$$

Equation 3-6 could then be used to determine the forecasted expenditure per interval of PPC as follows:

$$\text{Expenditure in interval } j = (\text{forecasted gradient in interval } j).(\text{magnitude of interval } j \text{ in PPC}) \quad 3\text{-}7$$

3.3.3 Choice of Smoothing Constant

The above forecasting method satisfies all but two of the requirements enumerated in section 3.2.4. One of these concerns the choice of the smoothing constant. This subject was dealt with in detail in Chapter Two. It will be recalled that current literature would tend to indicate that the use of unrestricted continuously adaptive models is favoured over others due to their rapid adaptation characteristics. Hence, the adaptive smoothing methods described in section 2.3.2 would, in theory at least, be appropriate since they all adjust the smoothing constant according to the previous forecasting performance. This subject is given further consideration in Appendix F.

3.3.4 Flexibility of Forecasting Model

The final requirement enumerated in section 3.2.4 was that the forecasting method should be flexible enough to allow management to simulate the consequences of their actions or inactions. A number of ways achieving this are possible. The one described here was developed by considering the least subjective interference possible.

Before the construction phase of a project can commence a certain amount of initial work needs to be done *(see* figure 2-1). This work includes design of the plant, buildings, shaft, etc., and implicity, a definition of the scope of the project. If this design is carried out thoroughly prior to commencement of construction, the definitive capital cost estimate and the initial project scheduling should be accomplished with a great degree of certainty. On the other hand, if the initial design is not thorough and proceeds well after construction starts, the capital cashflow will have smaller certainties and correspondingly higher contingencies; the project scope will not be highly defined; and the scheduling of the project will also be less certain. It follows therefore that the certainty associated with the initial phase of the project is some function of the progress achieved in the design of that project.

Further, the certainty associated with any project will *decrease* as the activity's scheduled time from the present increases. These factors combined may be summarised as follows:

a) The certainties associated with the cost and duration of a certain interval of PPC is greatest for that interval of PPC in the immediate future.

b) The certainties associated with the cost and duration of a certain interval of PPC decreases as the interval approaches the end of the project.

c) The certainties associated with the cost and duration of the interval of PPC in the immediate future is a function of the level of the design accomplished.

It is therefore possible, in cases where the design has been very thorough, to be "99% certain" of the cost scheduled for a certain interval of PPC. The question of how this certainty would affect the forecast now needs to be answered. In the hypothetical situation where the certainty of a parameter is 100% (a fixed price contract for example) it would be necessary to disregard the effect of the forecast completely and the new parameter would equal the old one. This situation is satisfied by the equation below. (A fuller justification is given in Appendix F):

New gradient = old gradient x certainty factor + old gradient x (1-certainty factor) x forecasted relative change in gradient) 3-8

When the certainty factor is zero, equation 3-8 reverts to equation 3-6. Equation 3-6 is therefore a special case of equation 3-8.

In general the certainty factor is between 0,5 and 1,0. Hence the above equation has a significant damping effect on the forecasted relative change in gradient.

The certainty factors described above offer management some of the flexibility called for in section 3.2.4. Suppose a project has been running late; management decides that the finish date forecasted in the previous update is the latest which can be tolerated and wishes to investigate the effect of ensuring that the project ends by that date. They could achieve this by setting all the certainty factors for time equal to unity which would negate the effect of the forecast for time. However when time was then related to cost through PPC, management would be given an indication of the change in cashflow which would occur. The total cost would remain the same however. Hence the method would not indicate what additional cost would be incurred, but merely how the same resources would have to be redistributed.

3.3.5 Summary of GRAM

The above forecasting model would appear to satisfy most of the requirements of section 3.2.4.

The forecasts for time and cost are performed independently but on an identical basis by relating them to physical percent completion separately. Once the forecasts have been made the conventional cost - time relation is easily obtainable from the analysis.

The model uses an adaptive exponential smoothing technique (the simple Trigg and Leach has been used here, but any other could be used) to determine the smoothing constant.

It forecasts the relative changes in parameters rather than the absolute change and hence avoids the occurrence of negative expenditure gradients, or even more unlikely, project progress with negative time.

It offers a measure of flexibility in terms of "what if" investigations through the introduction of the certainty factors. However, this flexibility is accompanied by a potentially significant damping effect of the forecasts which needs to be examined thoroughly.

3.4 EVALUATION CRITERIA FOR GRAM

There are a number of criteria by which the effectiveness and usefulness of GRAM may be evaluated:

a) How accurate the forecasts it makes are, compared to what actually happens;
b) How accurate the forecasts it makes are, compared to the accuracy of existing control techniques;
c) How rapidly it is capable of warning management of problems which may be present, compared to existing control techniques;
d) How sensitive the method is to the numerous factors which can affect it.

In order to perform this evaluation, it is necessary to apply the method to a specific project and hence make the above comparisons.

CHAPTER FOUR

EVALUATION OF THE GENERALISED RESOURCE APPRAISEMENT MODEL

4.1 INTRODUCTION

In Chapter Three the Generalised Resource Appraisement Model was developed after Pekar's Resource Appraisement Model had been qualitatively evaluated.

In this Chapter a method by which the effectiveness of GRAM may be evaluated is described. The objective of this evaluation is to determine whether or not the Generalised Resource Appraisement Model is more effective than existing forecasting systems.

In order to achieve this a number of things have to be performed. In section 4.3 a computer program which was developed for the purpose of testing GRAM is described. This section includes certain changes to the model described in Chapter Three and Appendix F which were necessitated by practical considerations.

Secondly a brief description is given of the project which was chosen as a case study to test GRAM.

Finally, in section 4.5 the method by which the computer program and the case study project are used in order to evaluate GRAM is described.

4.2 OBJECTIVES OF THE EVALUATION OF GRAM

As enumerated in section 3.4, the evaluation of GRAM should determine whether or not this model is

a) more reliable (accurate) than existing subjective forecasting methods, and
b) is quicker than existing methods in warning management of impending problems.

In addition to the above, it is necessary to determine how accurate the forecasts are in absolute terms and how sensitive the method is to the various inputs it requires.

Achievement of the above objectives will entail the development of a program which would then be applied to a specific project in order for the comparisons implied by a) and b) above to be performed. The comparisons need to be done as objectively as possible - the constants affecting GRAM need to be determined in such a way as to minimise retrospective bias.

4.3 DEVELOPMENT OF THE COMPUTER PROGRAM

4.3.1 Description of Program

It was intended that the model derived in Appendix F should be used in its entirety to develop the computer program. However, after considering the data which was available from the case study project described in the following section, it became apparent that the data required to calculate the certainty factors for cost as given by equation F-4 was not available from the existing records. Specifically, it was not possible to determine the cost of the work in progress at any point in time. It should be pointed out that the data was available during project execution, but had not been considered important enough to be recorded.

It was therefore necessary to use the certainty equation for time given by equation F-5, for both cost and time. As was mentioned in Appendix F, the reasoning used to arrive at equation F-5 for time was equally applicable to cost as well.

A listing of the Fortran computer program, with relevant explanatory comments, is reproduced in Appendix G.

Table 4-1 is the Algorithm of the computer program. As can be seen, the Algorithm follows very closely the model described in Appendix F.

After initialising the relevant variables the program reads in the latest update information, which consists of the elapsed time since the previous update, the costs incurred since the previous update, the report number and the percent physical completion as of this update. If the inputed percent completion is greater than 100% program execution ends.

The next step involves determining the ordered value of percent completion which is just greater than the updated value of percent completion (J(k)). In addition, the value of J(k) used in the previous update (J(k-1)) is found.

The certainty factors are calculated next using equation F-5 for both time and cost (the constants D_{1c} and D_{2c} are not necessarily equal for time and cost).

The comparison slopes, from which the actual relative change in gradient is calculated, are determined in the next section of the program. This section is complicated by the fact that reported values of percent completion could be in the same ordered interval of PPC, in adjoining ordered intervals of PPC and in ordered intervals of PPC far removed from each other. It is for this calculation that the value of J(k-1) needs to be determined, as the two values J(k) and J(k-1) set the limits of the forecasted gradient in terms of PPC. The actual relative change in the gradients is then determined from the comparison slopes.

The next section of the program calculates the smoothing constants using the simple Trigg and Leach approach. From the actual relative change in the gradients the errors in the previous forecasts, E_c and E_t, may be calculated and hence the absolute errors, E_{ca} and E_{ct}, can be determined. These errors are used to calculate the smoothed errors $E_c(k)$ and $E_t(k)$ using equation F-8, and the absolute smoothed errors $E_{ca}(k)$ and $E_{ta}(k)$ using equation F-9. Finally the tracking signals and hence the smoothing constants are determined using equation F-10.

These smoothing constants are used in the next section of the program to calculate the forecasted changes in the gradients, $C_{cf}(k)$ and $C_{tf}(k)$.

Using the forecasted relative changes in the gradients, and the certainty factors calculated previously, the forecasted gradients are determined from which the forecasted cost and time for each ordered interval of PPC is calculated.

The remainder of the program consists of the instructions required to produce the printout report, a sample of which, together with explanatory comments, is reproduced in Appendix G.

4.3.2 General Comments

A number of comments concerning the program are warranted at this stage.

The program uses the values of percent completion as an index for the array containing actual parameters, forecasted parameters, etc. This meant that only integer values were permissible for updates of percent completion. As a result input data has to be interpolated to these integer values of PPC.

It was also found that it was not possible to use arrays of one thousand elements as the level of Fortran offered on the Univac 1100 computer being used could not handle the resulting arrays easily.

A great deal of data manipulation was therefore required in order to use the program.

TABLE 4-1 : COMPUTER PROGRAM ALGORITHM

NOTE: The notation used here is defined in Appendix F.

Step No.	Operations	Program Step Nos.
1	Data Initialisation: Read in the budgeted parameters and initialise all variables requiring initialisation.	770 - 92C
2	Update Information: Read in the latest update information: I(k) = the reported PPC $A_t(k)$ = the reported time $A_c(k)$ = the reported cost k = the update number. If I(k) is greater than 100% end program execution.	930 - 1000
3	Determine J(k): Determine the planned or ordered value of PPC just greater than I(k).	1010 1060
4	Calculate the Certainty Factors: The certainty factors for both time and cost are calculated assuming a decreasing linear relationship between certainty and PPC.	1070 - 1210
5	Determine J(k-1): The value of J(k-1) used in the previous update is found.	1220 - 133C
6	Calculate the Comparison Slopes: The values of $G_{ca}(k)$, $Gt_a(k)$, $C_cf(k-1, I(k-1))$, Gtf(k-1, I(k-1)) are calculated.	1340 - 1590
7	Calculate the Actual Relative Change in Gradient: The values of $C_{ca}(k)$ and $C_{ta}(k)$ are calculated.	1600 - 1610
8	Calculate the Smoothing Constants: The values of $S_t(k)$ and $S_c(k)$ are calculated. This entails calculating Et, $^{E}\mathbf{c}$, Et(k), $E_c(k)$ and the equivalent absolute quantities as well.	1620 - 1750

TABLE 4-I (continued)

Step No.	Operations	Program Step Nos.
9	Calculate the Forecasted Relative Change in Gradient: The values of $C_c f(k)$ and $C_t f(k)$ are calculated using equation F-11.	1760 - 1770
10	Calculate the Forecasted Gradients: The values of $G_c(k,j)$ and $G_t(k,j)$ are calculated using equation F-12.	1780 - 1950
11	Calculate the Forecasted Parameters: The values of $F_c(k,j)$ and $F_t(k,j)$ are determined using equations F-13 and F-14.	1960 - 2020
12	Manipulate Update Data into Output Report: The output report is produced and formatted.	2030 - 3820
13	Return to Step 2 for Next Update: This section returns execution to step 2. If the next value of I(k) is greater than 100, execution is transferred to step 13 and is terminated.	3830 - 3890

4.4 THE CASE STUDY PROJECT

4.4.1 Criteria for Selection of Project

It was felt that the project which would be used as a case study should be complete so as to allow a retrospective analysis of the whole project.

It was also felt that the project should have been documented to a sufficient enough degree to allow any data which may have been required to be easily obtainable.

These criteria were best fulfilled by the construction of Beisa Mines Limited. Although the project was only 96% PC it was felt that this was sufficient for the purposes of this evaluation.

It was only later that it was found that the cost of in-progress work was not available from the records.

.4.2 Description of *Case* Study Project

Beisa Mines Limited is a gold and uranium mine situated near Welkom in the Orange Free State and owned by General Mining Union Corporation Limited. Construction of the mine began on a greenfield site on 1st July 1978. Figure H-1 shows the scheduled and actual physical percent progress. This figure was constructed from Table H-1 which was obtained from monthly records of the project.

Figure H-2 shows the commitments budgeted and actual as obtained from Table H-2. These tables represent the data which was used to run the program. Note that the curves in figures H-1 and H-2 are conventional in that they are time based. Figures H-3 and H-4 are the PPC based curves obtained from Tables H-3 and H-4 respectively.

An explanatory note on the data used is relevant. It will be noted that for cost the monthly commitments have been used. Referral to Chapter Two will show that commitments are the total value of orders placed and contracts awarded. These quantities are known instantaneously during project execution. On the other hand there is a significant time lag associated with cashflow, i.e. payments made, although the cashflow is more accurately determinable. For these reasons, commitments are used since they are accurate enough to indicate problem areas if they should arise.

In addition to the above, Table H-5 shows the *raw* data for the forecasted commitments on a monthly basis. These forecasts were obtained subjectively on an order by order, contract by contract basis. Table H-6 shows the same data PPC based and hence suitable for direct comparison with the results of the GRAM forecasting model.

4.5 METHOD ADOPTED IN EVALUATING GRAM

Having developed the program and selected a case study project, the manner in which they were to be used was to be decided on.

The effect of the constants D_{1t}, D_{2t} and D_{1c}, D_{2c} on the forecasts needed to be examined, in addition to the effect of the error smoothing constant g. D_1 would normally vary between 0,90 and 0,99. D_2 would be expected to vary between 0,001 and 0,002.

It was therefore decided to perform a sensitivity analysis involving these factors. Due to the large quantity of printout generated (100 pages per run) it was felt that the number of runs should be kept to a minimum. Table H-1 shows the range of values which were *tested.* It was felt that D_2 was dependant on D_I in so far as the more thorough the initial design *was* the less rapidly the certainty would decrease with increasing forecasting horizon. Hence the D_2 values used with D_1 a 0,99 are much lower than those used with D_1 = 0,90.

TABLE 4-1 PARAMETER VALUES USED IN SENSITIVITY ANALYSIS

D_1	0,99		0,90		O,O
G \ D_2					
0	0,001	0,0001	0,01	0,001	0,0
0,01	0,001	0,0001	0,01	0,001	0,0
0,05	0,001	0,0001	0,01	0,001	0,0
0,10	0,001	0,0001	0,01	0,001	0,0
0,30	0,001	0,0001	0,01	0,001	0,0

It should be emphasised that it was never intended that the sensitivity analysis should indicate what combination of values should be used for D_I and D_2. The values chosen for the final objective run were obtained by interviewing a number of people and determining from them what values would have been used had they been able to use the program at the beginning of the case study project. The sensitivity analysis *was* merely intended to show how the results would have varied with alternative choices.

It sensitivity analysis was however intended to indicate the effect that g Id on the forecasts, and hence which value of g should be used. This choice was to be based on the criterion of giving an acceptable response rate.

The method adopted was therefore as follows:

a) Perform a sensitivity analysis. From the sensitivity analysis deduce the value of g giving the most desirable response rate.

b) From the interviews, as objectively as possible, choose the values of D_I and D_2 for cost and time.

c) Perform an objective run which would then be used to evaluate the GRAM by the criteria enumerated in section 4-2.

CHAPTER FIVE

RESULTS OF THE EVALUATION OF THE GENERALISED RESOURCE APPRAISEMENT MODEL

5.1 INTRODUCTION

The previous Chapter described the method by which it was proposed that the Generalised Resource Appraisement Model should be evaluated. The criteria by which this was to be done, the computer program, the case study project which was to be used, and the details of the method, were described.

In this Chapter the results of this evaluation are described. This is done by describing the results of the sensitivity analysis and the final objective run made on the computer.

The results are discussed in Chapter Six.

5.2 RESULTS OF THE SENSITIVITY ANALYSIS

The results of the sensitivity analysis are tabulated in Appendix I. The tables show the forecasted total cost and duration of the project as forecasted when the project was at a certain stage of completion for the values of the parameters g, D_I and D_2 given in Table H-1. The relevant tables in Appendix I are I-1 to 1-5.

The data in these tables was then used to construct graphs I-1 to 1-6 in Appendix I. These graphs show the effect that each parameter involved in the sensitivity analysis has on the forecasts.

5.2.1 Effect of g on Total Forecasts

Figure I-1 is a graph showing the effect that the error smoothing factor, g, has on the total forecasted commitments with varying PPC (physical percentage completion). Two effects *are* notable. The first is that the error smoothing factor produces a phase lag. The higher g is the quicker the Generalised Resource Appraisement model reacts to large changes in input trends. This may be seen clearly in the range of PPC from 26 to 70. The solid line (when g is 0,3) consistently preceeds the other curves when an upward or downward trend is encountered. These observations are also true for time as can be seen from figure 1-2.

The second notable effect appears to be more complex. This is the degree of damping which occurs as a result of changes in g. The least fluctuation in total forecasted commitments is exhibited when g is 0,3. The forecasts in this case range from R127 million to R190 million. When g is 0,02, the values fluctuate between R132 million and 8172 million. When g is 0,1, the range of forecasts varies between R125 million and R207 million. These observations are tabulated in Table 5-1 below for commitments as well as time.

g	Time (Days)			Commitments (R Millions)		
	Maximum Forecast	Minimum Forecast	Range	Maximum Forecast	Minimum Forecast	Range
0,01	2 483	1 121	1 362	172 247	132 578	39 669
0,1	2 244	1 147	1 097	207 056	125 094	81 962
0,3	2 290	1 145	1 145	190 518	127 197	63 321

D1t = 0,90
D2t = 0,001

Plc ' 0 90
D2c = 0 001

TABLE 5-1 : THE EFFECT OF g ON RANGE OF FORECASTS

It can be seen from Table 5-1 that the effect of g on the fluctuations varies considerably. As a result of this it was decided to analyse the effect of g on the standard deviation of the forecasts. Table I-5 summarises the results of this investigation. This table was then used to construct the curves in figures 1-7 and 1-8.

It is clear that no general trends may be deduced from these curves. In the case of commitments, the error smoothing constant has a small effect when D_{1t} is close to unity. However, when D_{1c} is 0,90, the effect of g is more significant. It should be noted however that the scale in figure 1-8 exaggerates the effect of g when D_{1t} is 0,90.

The curves in figure 1-7 for time appear to offer more promise. When D_{1t} is 0,90, the standard deviation is greatest at g = 0,01, and decreases to when g is 0,3. The same trend is observed, on a less marked degree when D_{1t} is 0,99.

5.2.2. Effect of D_1 on Total Forecasts

It will be recalled from Chapter Four that an opinion survey was conducted informally with those persons who were involved with the case study project's capital estimate to determine the constants D_1 and D_2 for time and cost. It was felt that this would be more objective and appropriate than choosing these constants once the sensitivity analysis had been performed. The observations that follow are therefore intended purely as a sensitivity analysis and did not affect the choice of these constants.

Figures 1-3 and 1-4 illustrate the effect that the constant D_I has on the forecast of total project duration for time and commitments. It can be seen that the forecasts fluctuate to a considerably greater degree when D_l is 0,90 than when it is 0,99. This is true for both time and commitments. However, there is no evidence of a lag or difference in response rates. The contours for commitments have the same general shape. However, those for time differ in that when D_{1t} is 0,99 the contour is relatively stable whereas when D_{1t} is 0,90 the gradients are much steeper.

5.2.3 Effect of D_2 on Total Forecasts

Figure I-5 illustrates the effect that the constant D_2 has on the forecasts of total commitments. It can be seen that the lower value of D_2 (0,0001) gives forecasts consistently higher than when D_2 is 0,001. The standard deviation when D_2 is 0,0001 is R11,56 million whereas when D_2 is 0,001 it is R11,15 million. The difference in the standard deviations is therefore not significant. The difference in the average forecasts however is more significant: When D_2 is 0,001 the mean forecast is R147,7 million as opposed to R155,14 million when D_2 is 0,0001. It can be seen that for commitments the effect of D_2 is to alter the mean forecast.

Figure I-6 contains the equivalent curves for time. In this case however there is a significant variance in the standard deviations: 287 days when D_2 is 0,001 as opposed to 106,7 days when D_2 is 0,0001. The difference in means is comparatively not as significant: 1634,8 days when D_2 is 0,001 as opposed to 1462,3 days when D_2 is 0,0001.

5.3 RESULTS OF THE OBJECTIVE FORECAST

On the basis of the observations in section 5.2.1 and the curves in figures 1-7 and I-B, the values of g chosen were 0,3 for time as well as cost. The reasoning behind this is discussed in the next chapter.

Furthermore, as a result of the informal discussions held with those persons who were involved with the capital estimate of the case study project, the other constants were set as follows:

$D1t = 0,97$, $D1c = 0,95$, and $D2t = 0,0017$, $D2c = 0,0020$.

Appendix J consists of the report produced by this objective run. An explanation of the report format and terminology may be found in Appendix G which includes a sample output report.

Appendix K contains a summary (table K-1) of Appendix J which was used to construct figures K-1 and K-2. This figure compares the forecasts produced by GRAM to those obtained from the monthly progress reports (tabulated in tables H-5 and H-6), for commitments. Unfortunately, no equivalent comparison could be made for time, due to the lack of records.

Figures K-1 and K-2 also include a curve showing the % variance for intervals of PPC as read from the printout in Appendix K. The values used are summarised in tables K-2 and K-3. Recall that these figures represent the variance between the budgeted and reported quantities and are therefore not necessarily the variances used to forecast the time and cost. These variances, which are referred to as the progressive forecasting variances, are tabluated in tables K-4A and K-4B. Finally, the cumulative per unit variances are also tabulated in tables K-4A and K-4B.

Referring to figure H-1, the following observations may be made. The subjective forecasts produced by the existing system are only made when management feels they are necessary and hence the stepped appearance of the subjective forecast curve. The reason for this is the amount of work *required* to produce these forecasts.

The GRAM forecast curve follows what appears to be a somewhat erratic course. However, on comparing it to the % progressive variance where it is evident that the GRAM forecasts follow the % progressive curve in some cases but lag behind in other cases. For example, when the project PPC was 40, the forecast follows the % progressive variance curve closely. However, they do not return to previous levels as rapidly.

The equivalent curve for time drawn in figure H-2 shows that the % progressive variance curve for time was much more erratic than for commitments. As a result, the forecasted curve did not react in all cases in the same way as the commitments curve. For example, at 40 PPC, the forecast curve reacts rapidly to the large change in the % progressive variance curve. However, it remains high for an extremely long period of time before finally stabilising in the 70 - 90 PPC region.

A further point worth noting is that the case study project is in fact as *yet* not 100 per cent physically complete. GRAM in fact forecasts that the project will cost R145 million as opposed to the latest subjective estimate of 8139 million. The high forecast once again follows very closely the steep increase in the % progressive variance curve.

CHAPTER SIX

DISCUSSION

6.1 INTRODUCTION

In Chapter Five the results of the evaluation of the Generalised Resource Appraisement Model were described.

In this Chapter the results are discussed in detail. This is done by firstly discussing the sensitivity analysis, then the objective computer run, and finally some general comments are made.

The improvement on this method is the exponential moving average or exponential smoothing method as it is more commonly known. In this technique the most recent data is given a higher weighting than the older data (for a formal derivation see Brown (48) and Winters (59)). In its simplest form the model assumes a demand in any period expressed as

$$d_t = D + e_t$$

Where: d_t = demand in period t
D = mean demand level
e_t = random fluctuation normally distributed about the mean demand.

The exponential smoothing equation is then

$$S_t = a\, d_t + (1 - a)\, S_{t-1}$$

Where: S_t = Smoothed demand in period t (which is an estimate of D);

and a - Smoothing constant (O.< a 4.1)

The forecast of the demand per period, using this model is simply S_t. A smoothing constant between 0,1 and 0,2 has been found to provide good, stable forecasts in practice (49) This relatively low range of values for the smoothing constant enables the model to smooth out random fluctuations and produce values of S_t that closely approximate the demand, D.

3.2.3 Calculation of Smoothing Constant

The constant mentioned in equation 3-1 is in fact the smoothing constant referred to in Chapter Two. Referral to equation D-22 shows that the smoothing constant in any time period in RAM is in fact a weighted average of what Pekar refers to as the uncertainty associated with the rate of expenditure in that period, compared to the sum of all the uncertainties for the project. In words, equation D-22 could be rewritten as:

$$\text{Smoothing Factor for period j in the future} = \frac{\text{Uncertainty of Expenditure in period j}}{\text{Sum of all uncertainties from present update to completion of project}} \qquad 3\text{-}2$$

One measure of the uncertainty is the contingency associated with any time period. In most projects the contingencies are allocated as a fixed percentage of the total estimated cost (between 3 and 10% for most projects). It is therefore not very easy to find an objective measure of uncertainty which will differ from time period to time period. Consider therefore a project which is planned to be completed in twenty time periods (for argument's sake say months). Using equation 3-2, the smoothing constant for any time period will be given by

$$\text{Smoothing constant in period j} = \frac{\text{Uncertainty in period j}}{\text{Total project uncertainty}}$$

$$= \frac{\text{(P.U. contingencies) x (Planned expenditure in period j)}}{\text{(Outstanding project expenditure) x (P.U. contingencies)}}$$

$$= \frac{\text{Planned expenditure in period j}}{\text{Outstanding project expenditure}} \qquad 3\text{-}3$$

Now it is shown later in this Chapter that the periodical planned expenditures in a project resemble the well-known 'bath-tub' curve (this fact follows directly from the fact that time and cost have an S-curve relationship).

The above may be summarised as follows for cost (the expressions for time are identical):

$$\text{Actual relative change in gradient} = \frac{\text{Actual expenditure since last update}}{\text{Forecasted expenditure for the same interval of PPC}} \quad 3\text{-}4$$

$$\text{Forecasted relative change in gradient} = \text{previous forecast} + k\,(\text{actual relative change in gradient} - \text{previous forecast}) \quad 3\text{-}5$$

Where It is a constant (the smoothing constant) for any update.

Using the forecasted relative change in gradient, the forecasted gradients are then calculated as

$$\text{Forecasted gradient} = (\text{old gradient}).(\text{forecasted relative change in gradient}) \quad 3\text{-}6$$

Equation 3-6 could then be used to determine the forecasted expenditure per interval of PPC as follows:

$$\text{Expenditure in interval } j = (\text{forecasted gradient in interval } j).(\text{magnitude of interval } j \text{ in PPC}) \quad 3\text{-}7$$

3.3.3 Choice of Smoothing Constant

The above forecasting method satisfies all but two of the requirements enumerated in section 3.2.4. One of these concerns the choice of the smoothing constant. This subject was dealt with in detail in Chapter Two. It will be recalled that current literature would tend to indicate that the use of unrestricted continuously adaptive models is favoured over others due to their rapid adaptation characteristics. Hence, the adaptive smoothing methods described in section 2.3.2 would, in theory at least, be appropriate since they all adjust the smoothing constant according to the previous forecasting performance. This subject is given further consideration in Appendix F.

4.4 THE CASE STUDY PROJECT

4.4.1 Criteria for Selection of Project

It was felt that the project which would be used as a case study should be complete so as to allow a retrospective analysis of the whole project.

It was also felt that the project should have been documented to a sufficient enough degree to allow any data which may have been required to be easily obtainable.

These criteria were best fulfilled by the construction of Beisa Mines Limited. Although the project was only 96% PC it was felt that this was sufficient for the purposes of this evaluation.

It was only later that it was found that the cost of in-progress work was not available from the records.

.4.2 Description of *Case* Study Project

Beisa Mines Limited is a gold and uranium mine situated near Welkom in the Orange Free State and owned by General Mining Union Corporation Limited. Construction of the mine began on a greenfield site on 1st July 1978. Figure H-1 shows the scheduled and actual physical percent progress. This figure was constructed from Table H-1 which was obtained from monthly records of the project.

Figure H-2 shows the commitments budgeted and actual as obtained from Table H-2. These tables represent the data which was used to run the program. Note that the curves in figures H-1 and H-2 are conventional in that they are time based. Figures H-3 and H-4 are the PPC based curves obtained from Tables H-3 and H-4 respectively.

An explanatory note on the data used is relevant. It will be noted that for cost the monthly commitments have been used. Referral to Chapter Two will show that commitments are the total value of orders placed and contracts awarded. These quantities are known instantaneously during project execution. On the other hand there is a significant time lag associated with cashflow, i.e. payments made, although the cashflow is more accurately determinable. For these reasons, commitments are used since they are accurate enough to indicate problem areas if they should arise.

In addition to the above, Table H-5 shows the *raw* data for the forecasted commitments on a monthly basis. These forecasts were obtained subjectively on an order by order, contract by contract basis. Table H-6 shows the same data PPC based and hence suitable for direct comparison with the results of the GRAM forecasting model.

4.5 METHOD ADOPTED IN EVALUATING GRAM

Having developed the program and selected a case study project, the manner in which they were to be used was to be decided on.

The effect of the constants $D_{1t'}$ D_{2t} and $D_{1c'}$ D_{2c} on the forecasts needed to be examined, in addition to the effect of the error smoothing constant g. D_1 would normally vary between 0,90 and 0,99. D_2 would be expected to vary between 0,001 and 0,002.

It was therefore decided to perform a sensitivity analysis involving these factors. Due to the large quantity of printout generated (100 pages per run) it was felt that the number of runs should be kept to a minimum. Table H-1 shows the range of values which were *tested.* It was felt that D_2 was dependant on D_1 in so far as the more thorough the initial design *was* the less rapidly the certainty would decrease with increasing forecasting horizon. Hence the D_2 values used with D_1 a 0,99 are much lower than those used with D_1 = 0,90.

CHAPTER FIVE

RESULTS OF THE EVALUATION OF THE GENERALISED RESOURCE APPRAISEMENT MODEL

5.1 INTRODUCTION

The previous Chapter described the method by which it was proposed that the Generalised Resource Appraisement Model should be evaluated. The criteria by which this was to be done, the computer program, the case study project which was to be used, and the details of the method, were described.

In this Chapter the results of this evaluation are described. This is done by describing the results of the sensitivity analysis and the final objective run made on the computer.

The results are discussed in Chapter Six.

5.2 RESULTS OF THE SENSITIVITY ANALYSIS

The results of the sensitivity analysis are tabulated in Appendix I. The tables show the forecasted total cost and duration of the project as forecasted when the project was at a certain stage of completion for the values of the parameters g, D_I and D_2 given in Table H-1. The relevant tables in Appendix I are I-1 to 1-5.

The data in these tables was then used to construct graphs I-1 to 1-6 in Appendix I. These graphs show the effect that each parameter involved in the sensitivity analysis has on the forecasts.

5.2.1 Effect of g on Total Forecasts

Figure I-1 is a graph showing the effect that the error smoothing factor, g, has on the total forecasted commitments with varying PPC (physical percentage completion). Two effects *are* notable. The first is that the error smoothing factor produces a phase lag. The higher g is the quicker the Generalised Resource Appraisement model reacts to large changes in input trends. This may be seen clearly in the range of PPC from 26 to 70. The solid line (when g is 0,3) consistently preceeds the other curves when an upward or downward trend is encountered. These observations are also true for time as can be seen from figure 1-2.

The second notable effect appears to be more complex. This is the degree of damping which occurs as a result of changes in g. The least fluctuation in total forecasted commitments is exhibited when g is 0,3. The forecasts in this case range from R127 million to R190 million. When g is 0,02, the values fluctuate between R132 million and 8172 million. When g is 0,1, the range of forecasts varies between R125 million and R207 million. These observations are tabulated in Table 5-1 below for commitments as well as time.

5.2.2. Effect of D_1 on Total Forecasts

It will be recalled from Chapter Four that an opinion survey was conducted informally with those persons who were involved with the case study project's capital estimate to determine the constants D_1 and D_2 for time and cost. It was felt that this would be more objective and appropriate than choosing these constants once the sensitivity analysis had been performed. The observations that follow are therefore intended purely as a sensitivity analysis and did not affect the choice of these constants.

Figures 1-3 and 1-4 illustrate the effect that the constant D_I has on the forecast of total project duration for time and commitments. It can be seen that the forecasts fluctuate to a considerably greater degree when D_l is 0,90 than when it is 0,99. This is true for both time and commitments. However, there is no evidence of a lag or difference in response rates. The contours for commitments have the same general shape. However, those for time differ in that when D_{1t} is 0,99 the contour is relatively stable whereas when D_{1t} is 0,90 the gradients are much steeper.

5.2.3 Effect of D_2 on Total Forecasts

Figure I-5 illustrates the effect that the constant D_2 has on the forecasts of total commitments. It can be seen that the lower value of D_2 (0,0001) gives forecasts consistently higher than when D_2 is 0,001. The standard deviation when D_2 is 0,0001 is R11,56 million whereas when D_2 is 0,001 it is R11,15 million. The difference in the standard deviations is therefore not significant. The difference in the average forecasts however is more significant: When D_2 is 0,001 the mean forecast is R147,7 million as opposed to R155,14 million when D_2 is 0,0001. It can be seen that for commitments the effect of D_2 is to alter the mean forecast.

Figure I-6 contains the equivalent curves for time. In this case however there is a significant variance in the standard deviations: 287 days when D_2 is 0,001 as opposed to 106,7 days when D_2 is 0,0001. The difference in means is comparatively not as significant: 1634,8 days when D_2 is 0,001 as opposed to 1462,3 days when D_2 is 0,0001.

5.3 RESULTS OF THE OBJECTIVE FORECAST

On the basis of the observations in section 5.2.1 and the curves in figures 1-7 and I-B, the values of g chosen were 0,3 for time as well as cost. The reasoning behind this is discussed in the next chapter.

Furthermore, as a result of the informal discussions held with those persons who were involved with the capital estimate of the case study project, the other constants were set as follows:

$D1t = 0,97$, $D1c = 0,95$, and $D2t = 0,0017$, $D2c = 0,0020$.

Appendix J consists of the report produced by this objective run. An explanation of the report format and terminology may be found in Appendix G which includes a sample output report.

Appendix K contains a summary (table K-1) of Appendix J which was used to construct figures K-1 and K-2. This figure compares the forecasts produced by GRAM to those obtained from the monthly progress reports (tabulated in tables H-5 and H-6), for commitments. Unfortunately, no equivalent comparison could be made for time, due to the lack of records.

Figures K-1 and K-2 also include a curve showing the % variance for intervals of PPC as read from the printout in Appendix K. The values used are summarised in tables K-2 and K-3. Recall that these figures represent the variance between the budgeted and reported quantities and are therefore not necessarily the variances used to forecast the time and cost. These variances, which are referred to as the progressive forecasting variances, are tabluated in tables K-4A and K-4B. Finally, the cumulative per unit variances are also tabulated in tables K-4A and K-4B.

Referring to figure H-1, the following observations may be made. The subjective forecasts produced by the existing system are only made when management feels they are necessary and hence the stepped appearance of the subjective forecast curve. The reason for this is the amount of work *required* to produce these forecasts.

The GRAM forecast curve follows what appears to be a somewhat erratic course. However, on comparing it to the % progressive variance where it is evident that the GRAM forecasts follow the % progressive curve in some cases but lag behind in other cases. For example, when the project PPC was 40, the forecast follows the % progressive variance curve closely. However, they do not return to previous levels as rapidly.

The equivalent curve for time drawn in figure H-2 shows that the % progressive variance curve for time was much more erratic than for commitments. As a result, the forecasted curve did not react in all cases in the same way as the commitments curve. For example, at 40 PPC, the forecast curve reacts rapidly to the large change in the % progressive variance curve. However, it remains high for an extremely long period of time before finally stabilising in the 70 - 90 PPC region.

A further point worth noting is that the case study project is in fact as *yet* not 100 per cent physically complete. GRAM in fact forecasts that the project will cost R145 million as opposed to the latest subjective estimate of 8139 million. The high forecast once again follows very closely the steep increase in the % progressive variance curve.

6.2 DISCUSSION OF SENSITIVITY ANALYSIS

As mentioned in Chapter Four, the cost and amount of printout generated by each run of the computer program meant that the sensitivity analysis was by force of circumstances a very coarse one. Hence, the three values chosen for the D_2 constants, the gradient by which the certainty decreases, were all one order of magnitude removed from each other. The smallest value chosen was 0,0001. This implies a decrease of 1,0% in certainty over the total project life of 100 PPC; obviously an exceptionally well designed and estimated project in real terms. The next value chosen was 0,001. This implies a drop of 10% over the total project life which is a more realistic situation. Finally, the last value used was 0,01 which implies a decrease in certainty of 100% over the total project life which is also a rather unrealistic state of affairs.

Viewed in this light it becomes clear why the gradient constants, D_{2t} and D_{2c}, have such a marked damping effect, as evidenced in figures I-5 and 1-6. This effect may be seen to be a direct consequence of equation F-12:

$$Gc(k,j) = G_c(k-1,j)\ U_c(k,j) + G_c(k-1,j)\ (1-U_c(k,j))Cf(k)$$

It is clear from this equation that when $U_c(k,j)$ is very close to unity the effect of the second part of the equation., that is the forecasting part, is very small due to the $(1-Uc(k.j))$ term. Hence when D_{2c} is very small, the $U_c(k,j)$ is close to unity for all j and the damping effect is present for all the j's. This effect may be seen more clearly by considering the above equation in more detail.

The above equation could be rewritten in the form:

$$a = b\ c + b(1-c)d,$$

or

$$a = b\ c + bd - bcd$$

$$= b(c-cd+d).$$

6-1

Now d can, in theory, have any value greater than zero. However, for most projects, d would be expected to have a value comparatively close to unity (i.e. from 0,5 to 1,5) with occasional values much greater than unity (i.e. below 5 - a value of 5 implies a forecast five times the previous forecast - a most unlikely state of affairs). The value c would, in most cases, be between zero and unity. Now during any one forecasting update the value of d is constant, and c is assumed to vary linearly (using the nomenclature of Appendix F):

$$c = D1\text{-}jD2 \qquad 6\text{-}2$$

Where, j is the physical percent completion.
Substituting for c into equation 6-1,

$$a = b(D1\text{-}jD2 - d(D1\text{-}jD2) + d)$$

$$= b(D1\text{-}jD2 - dD1\text{-}jdD2 + d) \qquad 6\text{-}3$$

where d is a function of the error smoothing constant g.

The above expression for a can be used to explain the results of the sensitivity analysis. When D_I is close to unity and D_2 is very samll the expression for a approximates

$$a = b(1\text{-}d + d), \qquad 6{,}4$$

or a = b.

This represents the very damped case investigated with $D_1 = 0{,}99$ and $D_2 = 0{,}0001$.

The above discussion explains the heavy damping exhibited by the forecasting model when D_1 is close to unity and D_2 is very small. The analysis for the other cases is somewhat more difficult to discuss in the same way. However, it would appear from the sensitivity analysis that D_1 has a bearing on the mean forecast rather than damping the forecasts. This may be explained by considering the case where, once again, for simplicity's sake, D_2 is very small, but D_1 is now not very close to unity. Equation 6-3 now becomes

$$a \text{ e } b(D_1\text{-}dD_1 + d),$$

where d is a function of g, and D_I has a value between zero and unity but not close to unity, say 0,90 and below. Rewriting the above equation,

$$a = b(D_1 + d(1\text{-}D_1)) \qquad 6\text{-}5$$

The damping of the forecasted parameter, d, in this case is not as high as in equation 6-4. However, a is now equal to a value significantly different from b. This explains why the major effect of D_1 is to alter the mean of the forecasts, but to also alter the standard deviation less significantly. These observations are applicable to the results for time as well as cost.

Further to the above discussion, the effect of g on the forecasts is less easily analysed directly. It seems clear from the sensitivity analysis that the effect of g is more pronounced when D_1 is low and/or D_2 is high. When D_1 is low however, the effect of g is to increase, reach a maximum and decrease, within the range of values investigated. Moreover, high values of g improve the response rate. As a result of this g was set at 0,3 for the objective run. It was felt that the standard deviation of the forecasts would be acceptable and that no sacrifices regarding the response rate would be made. Unfortunately, values of g greater than 0,3 were not investigated. Trigg and Leach recommended a value of 0,1 and suggest smaller values if more cautious adapting of the smoothing constant is desired. The value of 0,3 was therefore originally intended to have been an extreme value. It therefore seems logical that future work should investigate the effect of using values of g greater than 0,3.

Some general comments regarding the sensitivity analysis and the variables involved may be made at this stage. It has been assumed that the certainty associated with both time and cost decreases linearly with physical percentage completion. This assumption needs to be verified or adapted accordingly in future work. Further, the relationship between D_i and D needs to be examined. It seems intuitively correct that if D_1 is high, then D_2 should be low. The implication here is that if the immediate future is known with a high certainty, then it follows that the rest of the project is also known with a relatively high certainty, and hence the gradient or rate at which this certainty decreases should be relatively lower.

Furthermore the relationship between the certainties of cost and time needs clarification. If the time scheduling of a project is done with great certainty, does it necessarily follow that the certainty associated with commitments is correspondingly high, or is the converse true?

To summarise the above discussion, the following points may be made:

a) The constants D_{2t} and D_{2c} have a marked effect on the degree of damping of the forecasted relative change in gradient.

b) The constants D_{1t} and D_{1c} have a marked effect on the mean total forecasts and a less significant effect on the standard deviation of the forecasts.

c) The error smoothing constant, g, has a significant effect on the standard deviation of the total forecasts when D_1 is relatively small and D_2 is relatively large. This effect warrants further investigation for values of g greater than 0,3.

d) The relation between the D_I's and D_2's needs to be examined.

e) The relation between the certainty factors for cost and those for time needs to be examined.

f) The assumption that the certainty factors decrease linearly with percent physical completion needs to be verified or adapted accordingly.

6.3 DISCUSSION OF THE OBJECTIVE COMPUTER RUN

It may seem inappropriate that the final GRAM forecast should be described as 'objective', since the certainty factors were arrived at by the subjective method of an opinion survey. However,it was felt that this would be a more objective way of choosing the certainty constants than to choose the values retrospectively from the sensitivity analysis which gave the results closest to the final project cost.

Further, it is difficult to attempt to evaluate GRAM quantitatively,and hence the description of the results in Chapter Five was rather qualitative.

In this section an attempt is made to evaluate GRAM as quantitatively and objectively as possible using the criteria enumerated in Chapter Four. Each criterion is dealt with in turn.

6.3.1 ACCURACY AND RELIABILITY OF GRAM COMPARED TO EXISTING METHOD

In absolute terms,GRAM failed miserably with regards to accuracy and reliability. The perfect forecasting method would have predicted the final cost and duration of the project before it had actually commenced. This of course is not possible in the vast majority of projects and hence the need to develop a naive forecasting method. What does need to be determined is whether or not in the case study project analysed GRAM was more effective than the existing subjective forecasting method described in Appendix H.

One way in which this may be achieved is by comparing the mean forecasts produced subjectively to those produced by GRAM. Table H-6 includes the mean forecast for the subjective method, and this was found to be 8166,3 million. GRAM's mean forecast, calculated from Table K-1,was found to be 8143,6 million. Assuming that the latest subjective forecast of R139,0 million is correct,the GRAM forecasts appear to be more accurate on the basis of this comparison.

When the standard deviations of the two methods are compared, we find that GRAM has a standard deviation of R14,9 million, whilst the subjective forecasts have a standard deviation of 814,7 million. Hence in this *case* there is no significant difference in the standard deviations of the total forecasts produced by GRAM and those produced subjectively.

If the proximity of the mean forecast to the final project cost is used as a measure of forecasting accuracy,it is clear that in the case study project the forecasts produced by GRAM are more accurate than the subjective forecasts.

Similarly,if the magnitude of the standard deviation is used as a measure of forecasting reliability, it is clear that GRAM and the subjective forecasts were equally reliable.

It should be pointed out that the above results are not neccesarily general. It has been shown, for example, that observations made for cost do not always apply to time as well, and hence the above conclusions should be viewed in their correct perspective. They refer to this project in particular, but could possibly be relevant to other projects as well. This can only be found out if the model is applied to more projects.

6.3.2 SPEED OF RESPONSE OF GRAM COMPARED TO THE EXISTING METHOD

The only way of determining whether or not the GRAM forecasts are faster than the subjective forecasts in warning management of impending problems is qualitative. It is clear from figure K-1 that the GRAM forecast indicated a general downward trend for the project commitments at the very start of the project. The subjective forecast on the other hand did not give any early indication of the fact that the project was grossly under budget. However,GRAM forecasted an increase in the total costs at the 40 PPC stage of the project which the subjective forecast was correct in not doing.

It can therefore be seen that GRAM appears to be sensitive to wild fluctuations, which are not necessarily true longterm indications of the total cost. The same could in fact be said for time as well. This problem and a possible solution is discussed in the next section.

The only deduction which can safely be made at this stage is that GRAM is capable of fore-warning management of impending problems much more effectively than the existing subjective forecasts,but it is also over-sensitive to drastic changes in the % progressive variance.

It is unfortunate that due to the lack of appropriate records, a similar comparison for time could not be done.

6.4 GENERAL DISCUSSION

The results obtained from this evaluation of GRAM need to be considered in the light of the economic conditions which prevailed during the project's execution. One major factor which warrants mention is the fact that construction commenced in a recessionary economic climate. This meant that most of the major contracts were awarded in an abnormally competitive situation, with the result that these contracts were generally well below their capital estimates. This partly explains the fact that the reported expenditures were consistently below budget for most of the project.

However, some exceptions did occur when expenditure was much greater than budgeted for that particular period. These isolated cases influenced the forecasts considerably. Considering figure K-1, it can be seen that at 40 PPC a % progressive variance of 240% was reported. GRAM responded immediately by increasing the forecast for the next period correspondingly. However,when the % progressive variance returned to previous levels,the forecasts remained high for a considerable interval of PPC. This can be explained by considering the adaptive smoothing method adopted. Immediately prior to the sharp increase in % progressive variance, the forecasts were relatively stable and this was reflected in the smoothing constants which were generally close to 0,1 (see Appendix J, reports 13 to 22, and figure 6-1). As soon as the large change in % progressive variance was encountered, the simple Trigg and Leach model responded by following the change rapidly. However,when the % variance returned to previous levels, the smoothing constant was high, and hence the forecast did not return to previous levels.

The curves in figure 6-1 show this clearly. The large fluctuations of the smoothing constant in figure 6-1 are a direct consequence of the fact that the error smoothing constant, g, has the relatively high value of 0,3. What is of more interest however is the fact that in the 34 to 36 PPC area the smoothing constants are reasonably stable. When the large change in % variance is met the smoothing constant adapts rapidly and returns to a low value in the next period.

It can be seen therefore that although the smoothing constant has returned to previous levels, the forecast itself has not. The reason for this would appear to be the presence of the certainty factors which have a damping effect and do not allow the forecast to return to its previous level rapidly. It would seem reasonable however to expect the damping effect of the certainty factors to have an equal effect when the forecast is increasing as when it is decreasing. The reasons why this is not so appear to be extremely complex.

This characteristic of GRAM seriously compromises its potential uses. A number of possible ways of overcoming it do exist. The first to be considered is to use much higher certainty factors. This would have the undesirable consequence of making their choice too subjective. An other and more plausible solution would be to monitor the cumulative forecast and compare this to the cumulative reported expenditure of time and commitments. This would tend to give random (or minor) over or under expenditures their true relevance in comparison to the total project. For example, it is possible with the present model to budget an expenditure for a certain interval of PPC of say R2 million. Suppose that the reported expenditure is R8 million. The % variance which would be used to calculate the forecast would be 300%, and this would effect the forecasts significantly. If it is now considered that the total project expenditure to date has been say R150 million out of a total budget of R200 million, it can be seen that the significance of the R6 million overspent is greatly exaggerated by the progressive % variance treatment.

FIGURE 6-1

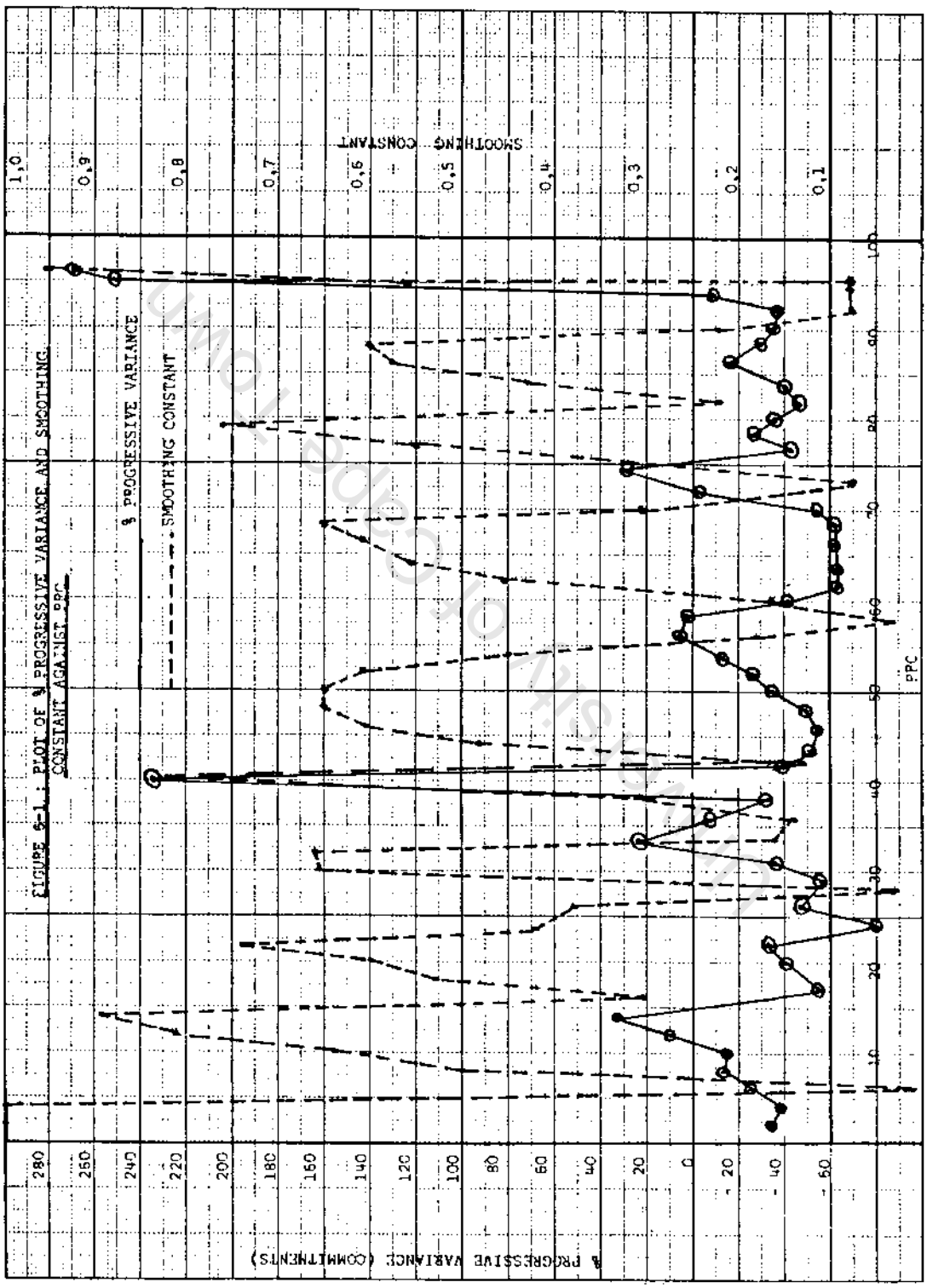
FIGURE 6-1 : PLOT OF % PROGRESSIVE VARIANCE AND SMOOTHING CONSTANT AGAINST PPC
% PROGRESSIVE VARIANCE
SMOOTHING CONSTANT
% PROGRESSIVE VARIANCE (COMMITMENTS)
PPC

The cumulative approach would compare the reported R150 million to the budgeted expenditure for the same interval of PPC, and use that % cumulative variance to forecast. This approach is leant more weight when it is considered that often during a project some commitments are found which have not been recorded but which should have been allocated some period of time prior to their discovery. Normal practice is to allocate them to the present period under report with an explanation for management. This is in fact what occurred in the case study project when it was 40 PPC. The result of this on the forecast has been discussed. Unfortunately it was only after the analysis had been performed that this became apparent Had a cumulative system been in use the effect would not have been as significant. Table K-3 has the cumulative budget variances for time and commitments listed as a function of PPC. It is clearly evident from this table that the effect of the over spending is not as drastic. Moreover a general trend is much more easily discernible than for the equivalent progressive records.

It is worth noting that the model used in this evaluation did not exhibit the flexibility envisaged in Chapter Three regarding the "What if" type of investigation. This is a direct result of the way in which the certainty factors were incorporated in the model. They do not allow the program user to set a project target date and investigation of the resulting cash flow.

In order that such investigations be made possible it is necessary to re-formulate the entire model. It has been seen from the above discussion that the certainty factors in effect dampen considerably the forecasted term in equation F-12. It has also been seen that cumulative variances are preferrable to progressive variances for a number of reasons. Cumulative variances have the characteristic that they do not fluctuate as considerably as progressive variances.

Hence the need of the certainty factors is not as acute with a cumulative model as with a progressive model. It is therefore proposed a cumulative model does not need the certainty factors, and the U_c terms in equation F-12 should be set to zero. Equation F-12 would then revert to

$$G_c(k,j) \quad G_c(k-1,j) \bullet Cf(k) \qquad 6\text{-}6$$

Suppose now that management wishes to investigate the cash flow which would result if the project was to be crashed (i.e. completed in the shortest possible time irrespective of the cost). The forecasted times would now be made equal to the previously forecasted times multiplied by a factor. This factor would be equal to the relative change in total duration required to complete the project by the target date. Hence all the durations would be adjusted so as to give the completion date required. However, the cost would still be forecasted in the usual way. Hence, some indication of cash flow changes would be obtained using a model of this kind-

There is a further advantage associated with a model of this kind. It could easily be used in conjunction with a computerised critical path network package. The package would be used to obtain a crash target date which would then be used in the model.

It is worth noting that the present model uses a simple exponential smoothing equation. There are, as mentioned in Chapter Two, other equations which include what is commonly referred to as a trend term. This was a direct interpretation in the context of project control for the cost forecasting. The trend term could be incorporated to account for cost escalation. Problems could however be encountered since escalation is traditionally time-based, whereas the model would require it to be PPC based.

The choice of smoothing constants also needs to be discussed. It will be recalled from Chapter Three and Appendix F that the simple Trigg and Leach method was chosen on the basis of its objectivity (the method could be used on any project) and current literature recommendations. Figure 6-1 shows clearly that the smoothing constant fluctuated considerably.

It will also be recalled from Chapter Three that the smoothing constant should be dependant on the PPC. This model would appear to offer more promise than the Trigg and Leach method. It seems reasonable that two or three smoothing constants would suffice for a project. One would be relatively low (say 0,05 to 0,2) for the stable beginning of a project, whilst the second would become effective once the rapid progress phase of the project was reached (see figure 3-1), say at 30 PPC. The rapid progress smoothing constant would have a relatively higher value in order to allow more sensitive adaptation to changes in trend. This discussion is given weight by the characteristics exhibited by the case study project. It is clear from figure K-1 and K-2 that the project was comparatively stable at the start and end, and hence low smoothing constants would have been appropriate.

Pinally a discussion of how GRAM could be used is warranted. In this evaluation the total project figures were used to forecast. Most cost engineering systems however sub-divide the project according to areas (Appendix E-3 contains a typical area sub-division for a gold and uranium mine) . The assumption inherent in time-series analysis, namely that previous trends will continue into the future, is probably more correct if applied on an area by area basis, rather than a total project basis.

To summarise this discussion, the following points may be made:

a) There is reason to believe that monitoring cumulative % variances would produce superior forecasts to those produced by monitoring progressive % variances.

b) The use of cumulative variance forecasting excludes the use of certainty factors in their present form, as they have an unduly large damping effect. It is also possible that they are responsible for the slow response rate exhibited by the model in counteracting the effect of random large fluctuations in trend

c) The certainty factors could however be used to give the model some flexibility, in the "what if" type of investigation.

d) The exponential smoothing equation could be adapted to include cost escalation if this was desired.

e) There is reason to believe that GRAM could be applied with more success on a cost area basis than on the total project basis.

CHAPTER SEVEN

CONCLUSION

In this Thesis a literature survey was conducted into methods which could be used to forecast the completion date and total cost of a project reliably but early enough to warn management of impending problems. It was found that most so called forecasting techniques were in fact control techniques whih yielded a wealth of useful information regarding the state of a project but failed to give a reliable quantitative idea of the project outcome. The only model which attempted to achieve this was the Resource Appraisement Model developed by Pekar. This model predicts the cashflow profile of a project by monitoring progressive variances between reported and forecasted expenditures. However it assumes that the project will finish on schedule,an assumption which severely limits its applicability.

An informal idustrial opinion survey was conducted to ascertain whether there was in fact a need for an analytical forecasting model. The conclusion reached was that there was indeed a need for such a model but that it should complement rather than replace the existing subjective forecasting methods, due to the dangers involved in placing too much faith in a mechanical tool.

As a result, a model was developed from Pekar's model which combined the forecasting of time and cost, and refined Pekar's model in a number of other respects. A computer program was then written to evaluate the model, known as the Generalised Resource appraisement Model,and a case study project was chosen to do this. A sensitivity analysis was then performed to determine the effect that the constants in the model have on the forecasts of total project duration and cost. The next step was to apply the model to the case study project as objectively as possible. In other words it was assumed that the project had not yet commenced in order to minimise retrospective bias.

The conclusions from this analysis were:

(a) That the model was more accurate than the existing subjective forecasting system on average;
(b) That the model was as reliable as the existing subjective forecasting system on average;
(c) That the model was too sensitive to random fluctuations in trend despite the damping introduced by certainty factors;

Nonetheless it was concluded that this characteristic could be overcome by comparing the cumulative variances rather than the progressive variances.

In conclusion therefore, it may be said that the objectives of this Thesis, namely that an objective forecasting technique which would forecast the completion date and total cost of a project in sufficient time to allow management to take meaningful action,were met to a sufficient extent to allow further work to develop the model Inevitably there are a number of areas which need to be investigated by future work:

a) the use of cumulative forecasting;
b) the use of certainty factors which exclude completely the forecast term and hence enable "what if" type of investigations;
c) the use of GRAM by cost area rather than total project;
d) the use of the exponential smoothing equation with a trend term to enable the incorporation of escalation.

APPENDIX A

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APPENDIX B

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APPENDIX C

C-1 USE OF STALLWORTHY'S EMPIRICAL CONTROL METHOD

Consider a project where at a particular point in time the project status is given by the data in Table c-1, and has been plotted on figures C-1, C-2 and C-3.

ESTIMATES:			
Capital Estimate		R6 070 000	
Contingencies		R 530 000	
Total		R6 600 000	
Erection Manhours to Complete	Mhrs	67 444	
Average Unit Rate $\left(\frac{6\ 070\ 000}{67\ 444}\right)$	R/h	90	
PRESENT STATUS:			
Value of Work Done		R2 428 000	(40%)
Erection Manhours Spent		20 907	(31%)
Cumulative Unit Rate $\left(= \frac{2\ 428}{20\ 907}\right)$	R/h	116	
Productivity Ratio (= 116/90)		1,28	
Efficiency Status (= 0,40/0,31)		1,29	

TABLE C-1 : EXAMPLE PROJECT STATUS

Now point A does not lie on the S-Curve in figure C-1, which appears to contradict the law of the S-Curve[9] This implies that the estimate of total cost or time, or both, are in error. Turning to figure C-2, the productivity ratio is also not on the planned curve. By transposing the point onto the curve, the value of work done would decrease to 33%. Using this value of 33% on the S-Curve still does not produce a point on the curve.

By transposing the project status point onto the curve in figure C-3 the time elapsed decreases from 55% to 50%. Making this adjustment on the other two curves produces the following deductions:

a) The value of work done is actually 33% and the final project cost will therefore be R7 350 000;

b) The project will be completed ahead of schedule; 50/55 gives 90% of the originally estimated duration.

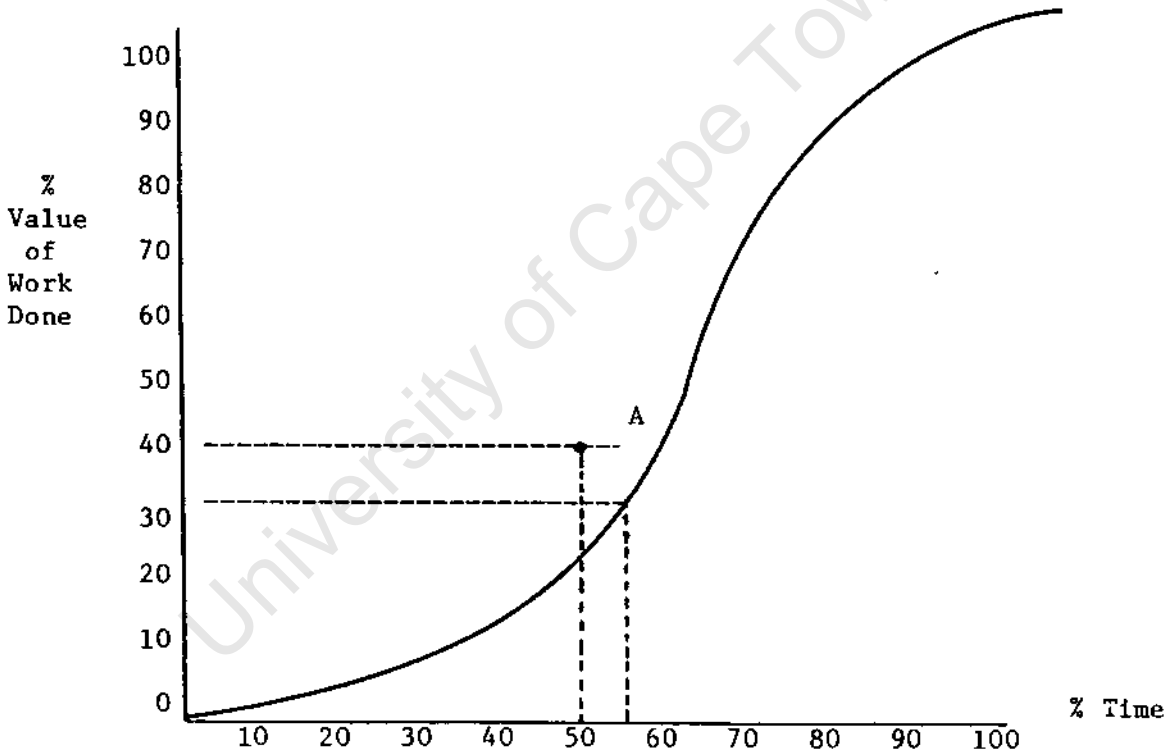


FIGURE C-1 : S-CURVE FOR VALUE OF WORK DONE(27)

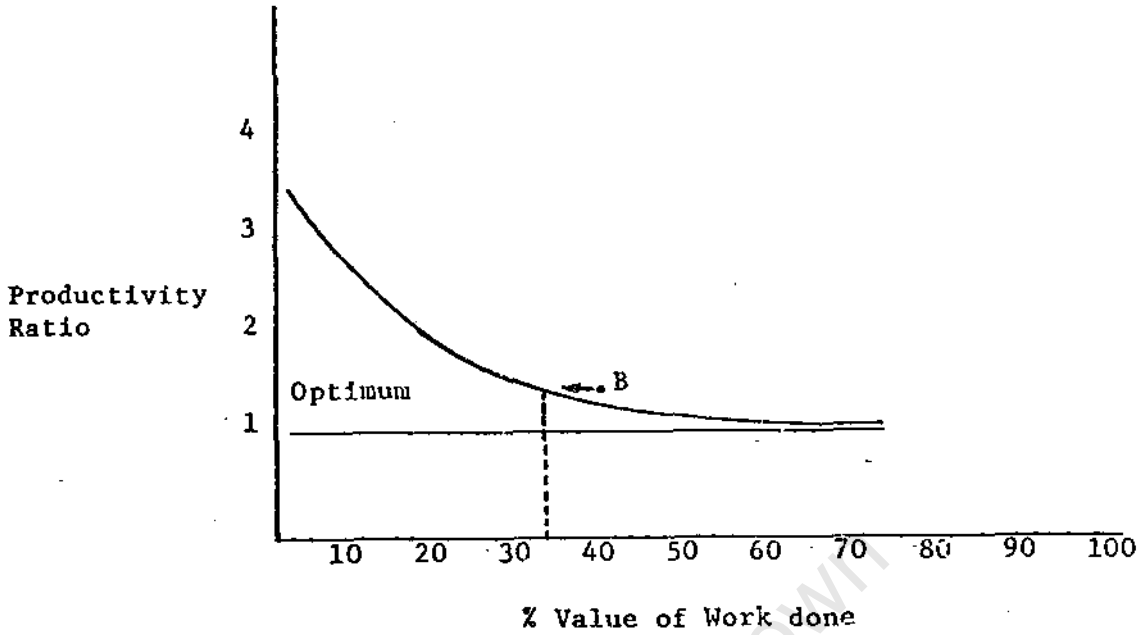


FIGURE C-2 : PRODUCTIVITY RATIO VS VALUE OF WORK DONE([28])

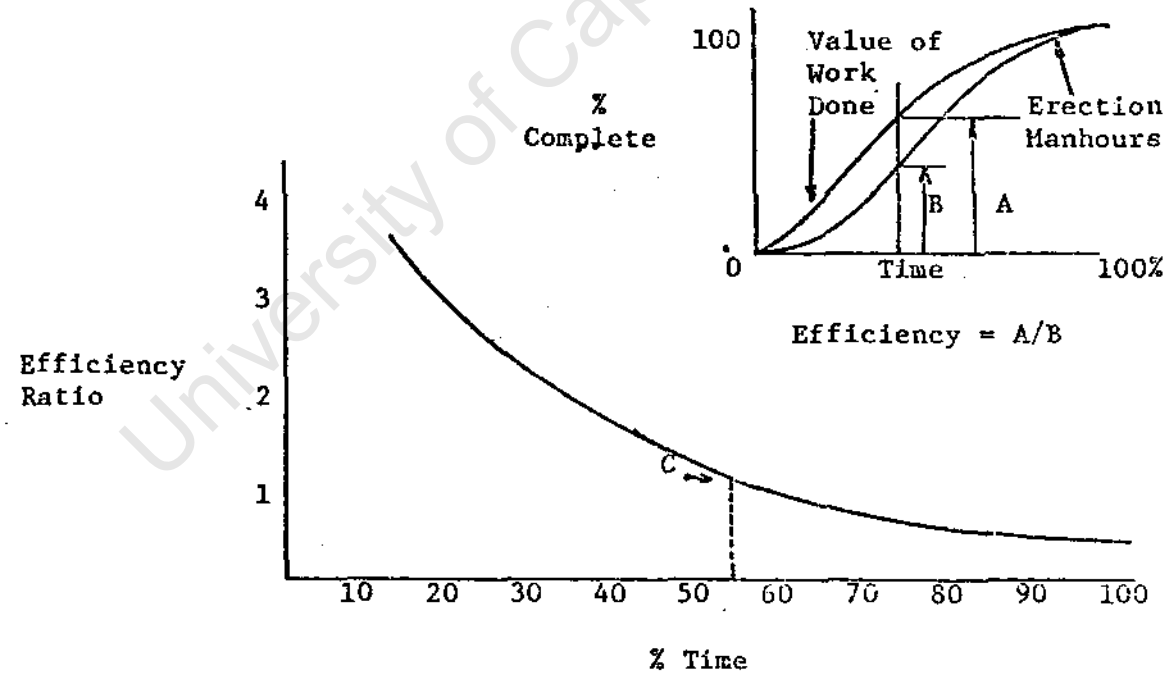


FIGURE C-3 : EFFICIENCY RATIO VS PROJECT DURATION(29)

APPENDIX D

DEVELOPMENT OF THE RESOURCE APPRAISMENT MODELS

D-1 RAM

The following terminology is defined: (See figure D-1)

= future period being predicted;

j = reporting period under analysis;

N = number of time periods or stages in the project life; then

$$0 \leq i \leq N, \quad 0 \leq j \leq N, \quad \text{and } j \not\leq i;$$

p(i,j) = planned values for the project; then p(i,o) are the planned values set at reporting period o, i.e. the original planned values, and p(i,5) would represent the planned values set at time period 5, i.e. at a project review. Note that p(i,j) can have any conveniently measurable units such as Rands, manhours or % physical completion;

a(j) = the actual or reported value for period j corresponding to the planned value p(i,o), where j = i in this case;

v(i,o) = the perceived (i.e. planned or estimated) variance between a(j) and p(i,o); a large value for v(i,o) represents a large uncertainty; the units of v(i,o) are absolute (i.e. it is not a % probability);

b(i,j) = the slope of the straight line segments on the contour; b(i,o) would represent the planned slopes, and would be given by the expression

b(i,o) = p(i+1,o) - p(i,o), where

i = 1, ... N - 1;

By definition,

b(N,o) = p(N+1,o) - p(N,o) where, also by defintion,

p(N+1,o) = 0;

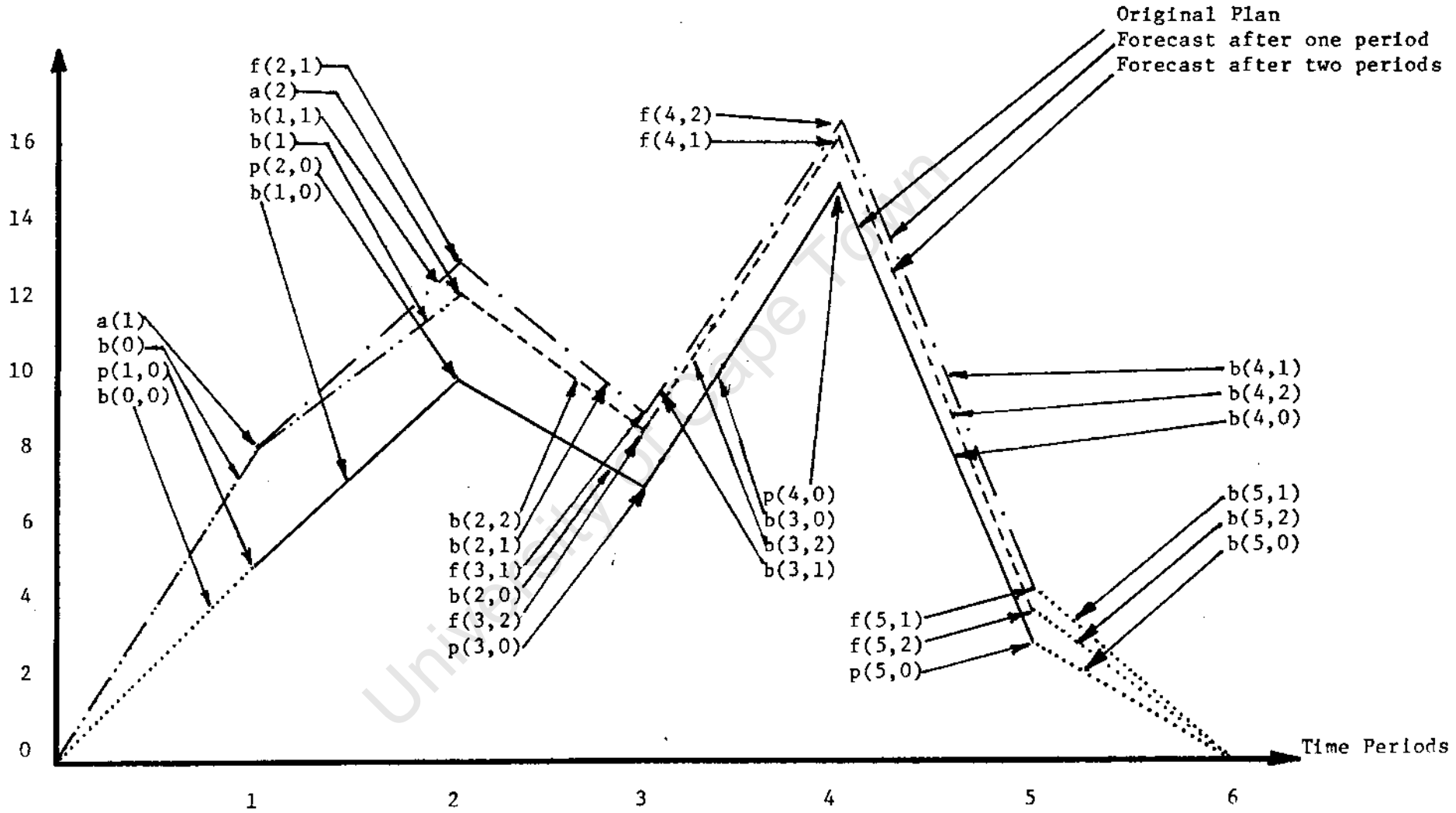


FIGURE D-1 : HYPOTHETICAL PROJECT PLAN

b(j) = the actual slope as determined from the actual or reported data, from the equation
b(j) = a(j+l) - a(j) for 1 < j < N-1; b(N) is defined as
b(N) = a(N+l) - a(N) where, by definition,
a(N+1) = 0;

f(1,j) = the forecast of the value to be expended in period i made during period j.

* = a column vector representing all the actual slopes, b(j).

$$= \begin{vmatrix} b(1) \\ b(2) \\ - \\ - \\ b(N) \end{vmatrix} .$$

s(j) a column vector containing the actual slopes b(j) for i<j and the most recently forecasted slopes for

e.g. $\bar{S}(3) = \begin{vmatrix} b(1) \\ b(2) \\ b(3,3) \\ b(4,3) \\ b(5,3) \\ - \\ - \\ b(N,3) \end{vmatrix}$

S(j-1) = a column vector containing the b(j) and b(i,j)'s of the previous period.

The bar '-' is used here to denote a matrix.

$$\bar{e}(j) = \bar{S}(j) - \bar{S}$$

$$\bar{e}(j-1) = \bar{S}(j-1) - \bar{S}$$

e.g. if j = 3 and N = 4, then

$$\bar{e}(j-1) = \begin{vmatrix} b(1) \\ b(2) \\ b(3,3) \\ b(4,3) \end{vmatrix} - \begin{vmatrix} b(1) \\ b(2) \\ b(3) \\ b(4) \end{vmatrix} = \bar{S}(3) - \bar{S}$$

and

$$\bar{e}(j-1) = \begin{vmatrix} b(1) \\ b(2,2) \\ b(3,2) \\ b(4,2) \end{vmatrix} - \begin{vmatrix} b(1) \\ b(2) \\ b(3) \\ b(4) \end{vmatrix} = \bar{S}(2) - \bar{S}$$

k(j) = a row vector with dimension (1 x N)'-' whose first j-1 entries are zero and all other entries are - 1.

e.g. for N = 5 and j = 3,
k(3) = (0,0, -1, -1, -1)

U(j) = a column vector containing all the weighting factors, u(i,j), at any reporting stage J.

Now the general form of the exponential smoothing equation is

$$S_t = S_{t-1} + a\ (d_t - S_{t-1})$$

Substituting the relevant equivalent values from the above definitions gives

$$b(i,j) = b(i,j-1) + u(i,j)\quad a(j) - f(j,j-1) \qquad (D-1)$$

where $j \leq i \leq N$

Equation D-1 forecasts the slopes for the periods following the current period, j. In order to obtain the forecasted values, f(i,j), u(i,j) needs to be determined and an equation needs to be developed which will use the predicted slopes, b(i,j), to find the forecasted values, f(i'-'j).

Now assuming that the reporting period is j'-' the actual value a(j) is known, and the slope of the linear segment from j to j+1 is b(j,j)'-' given by equation D-1.

Then $f(j+1,j) = a(j) + b(j,j)$

Similarly $f(j+2,j) = f(j+1,j) + b(j+1,j)$

$= a(j) + b(j,j) + b(j+1,j)$

and $f(j+3,j) = f(j+2,j) + b(j+2,j)$

$= a(j) + b(j,j) + b(j+1,j) + b(j+2,j).$

Hence, in general, $$f(i,j) = a(j) + \sum_{L=j}^{i-1} b(L,j) \qquad D\text{-}2$$

All that now remains is to determine u(i,j).

Now recall that b(N,j) = f(N,j) - f(N+1, j) by definition, where f(N+l,j) = 0 also by definition.

It can therefore be seen that

$$f(j,j-1) = -\sum_{L=j}^{N} b(L,j-1) \qquad D\text{-}3$$

and similarly,

$$a(j) = -\sum_{L=j}^{N} b(L) \qquad D\text{-}4$$

Recalling the definitions of k(j) and S(j-1),

$$\bar{k}(j)\ \bar{S}(j-1) = -\sum_{L=j}^{N} b(L,j-1) \qquad \text{D-5}$$

and similarly,

$$\bar{k}(j)\bar{S} = -\sum_{L=j}^{N} b(L), \text{ since} \qquad \text{D-6}$$

k(j) is 1 x N matrix and S is an N x 1 matrix, giving a 1 x 1 matrix, or a scalar, when multiplied.

Substituting equation D-5 into D-3, and D-6 into D-4, gives

$$f(j,j-1) = \bar{k}(j)\ \bar{S}(j-1), \text{ and} \qquad \text{D-7}$$

$$a(j) = \bar{k}(j)\bar{S} \qquad \text{D-8}$$

Recalling the definitions for S, S(j-1) and U(j), the forecasting equation D-1 may be rewritten in the form

$$\bar{S}(j) = \bar{S}(j-1) + \bar{U}(j)\left[\bar{k}(j)\bar{S} - \bar{k}(j)\bar{S}(j-1)\right] \qquad \text{D-9}$$

Subtracting S from both sides leaves

$$\bar{S}(j) - \bar{S} = \bar{S}(j-1) - \bar{S} + \bar{U}(j)\left[\bar{k}(j)\bar{S} - \bar{k}(j)\bar{S}(j-1)\right] \qquad \text{D-10}$$

We know by definition that

$$\bar{e}(j) = \bar{S}(j) - \bar{S}, \text{ and } \bar{e}(j-1) = \bar{e}(j-1) - \bar{S}$$

Hence equation D-10 may be rewritten in the form

$$\begin{aligned}\bar{e}(j) &= \bar{e}(j-1) + \bar{U}(j)\left[\bar{k}(j)\bar{S} - \bar{k}(j)\,\bar{S}(j-1)\right] \\ &= \bar{e}(j-1) + \bar{U}(j)\bar{k}(j)\left[\,\bar{S} - \bar{S}(j-1)\,\right] \\ &= \bar{e}(j-1) - \bar{U}(j)\bar{k}(j)\bar{e}(j-1) \\ &= \left[\,\bar{I} - \bar{U}(j)\bar{k}(j)\,\right]\bar{e}(j-1) \qquad \text{D-11}\end{aligned}$$

Where I is the Identity matrix.

Multplying equation D-11 by the transpose of each side,

$$\bar{e}(j)\,\bar{e}(j)^T = ((\bar{I} - \bar{U}(j)\bar{k}(j))\,\bar{e}(j-1))\;\;((\bar{I} - \bar{U}(j)\bar{k}(j)\,\bar{e}(j-))$$

$$= (\bar{I} - \bar{U}(j)\bar{k}(j))\,\bar{e}(j-1)\,\bar{e}(j-1)^T\,(\bar{I} - \bar{U}(j)\bar{k}(j))$$

Taking the expected value of both sides we obtain,

$$E\,(\bar{e}(j)\,\bar{e}(j)^T) = E\left[\,(\bar{I} - \bar{U}(j)\bar{k}(j)\bar{e}(j-1)\bar{e}(j-1)^T\;\;(\bar{I} - \bar{U}(j)\bar{k}(j))^T\,\right]$$

$$= (\bar{I} - \bar{U}(j)\bar{k}(j))\bar{E}\,(\bar{e}(j-1)\bar{e}(j-1)^T)\;(\bar{I} - \bar{U}(j)\bar{k}(j))^T \qquad \text{D-12}$$

Let us now examine E(e(j)e(j)) more closely. We know by definition that E(e(j)e(j)) is the co-variance matrix of e(j). Consider that we are in a planning situation defined by j=1 for N=4

$$\text{Then}\quad \bar{e}(j-1) = \bar{S}(j-1) - \bar{S}$$

$$\text{and}\quad \bar{e}(o) = \bar{S}(o) - \bar{S}$$

$$= \begin{vmatrix} b(1,0) \\ b(2,0) \\ b(3,0) \\ b(4,0) \end{vmatrix} - \begin{vmatrix} b(1) \\ b(2) \\ b(3) \\ b(4) \end{vmatrix}$$

Hence, e(o) represents the residuals between plan and actual. If we assume that the actual slopes b(j) are normally distributed about the planned slopes, b(i,o) for every j a 1, then in general

$$b(j) \in b(i,o) \pm 3\sigma.$$

Since our sample consists of only the two points b(j) and b(i,o) for i = j, the standard deviation, is given by

$$\sigma = b(i,o) - b(j) \qquad \text{Where } i = j$$

$E\,(e(o)\,e(o)^T)$ can therefore be seen to define the variance of these residuals at stage j - 1. The only non-zero elements, which will be on the diagonal, are these co-variances, assuming that the actual slopes, b(j)'s, are independent. Pekar proposes that these co-variances are actually the v(i,o)'s or uncertainty measures as defined previously. Mence,

$$E(\bar{e}(o)\,\bar{e}(o)^T) = \begin{vmatrix} V(1,0) & 0 & 0 & 0 \\ 0 & V(2,0) & 0 & 0 \\ 0 & 0 & V(3,0) & 0 \\ 0 & 0 & 0 & V(4,0) \end{vmatrix}$$

The next step is to minimise these variances with respect to U(j). We begin by defining

$$\begin{aligned} \bar{V}(o) &= E\,(\bar{e}(o)\,\bar{e}(o)^T), \\ \bar{V}(j) &= E\,(\bar{e}(j)\,\bar{e}(j)^T), \\ \bar{V}(j-1) &= E\,(\bar{e}(j-1)\,\bar{e}(j-1)^T), \quad \text{and} \\ \bar{M}(U) &= \bar{I} - \bar{U}(j)\bar{k}(j) \end{aligned} \qquad \text{D-13}$$

Substituting the above terms into equation D-12 gives the symmetric matrix V(j) where

$$\bar{V}(j) = \bar{M}(U)\,\bar{V}(j-1)\,\bar{M}(U)^T. \qquad \text{D-14}$$

Taking the partial derivative of V(j) with respect to U(j), we have

$$\frac{\partial \bar{V}(j)}{\partial \bar{U}} = \frac{\partial \bar{M}(U)}{\partial \bar{U}} \cdot \bar{V}(j-1) \cdot \bar{M}(U)^T + \bar{M}(U)\, \bar{V}(j-1)\, \frac{\partial \bar{M}(U)^T}{\partial \bar{U}}$$

$$= 2\, \frac{\partial \bar{M}(U)}{\partial \bar{U}}\, \bar{V}(j-1)\, \bar{M}(U)^T. \qquad \text{D-15}$$

By definition D-13

$$\bar{M}(U) = \bar{I} - \bar{U}(j)\, \bar{k}(j)^T.$$

Hence $\frac{\partial \bar{M}(U)}{\partial \bar{U}} = -\frac{\partial \bar{U}(j)}{\bar{U}}\, \bar{k}(j) = -\bar{k}(j)$

Substituting this into equation D-15,

$$\frac{\partial \bar{V}(j)}{\partial \bar{U}} = -\bar{k}(j)\, \bar{V}(j-1)\, (\bar{I} - \bar{U}(j)\, \bar{k}(j))^T. \qquad \text{D-16}$$

Puting equation D-16 equal to zero, and solving for $\bar{U}(j)$ gives

$$-\bar{k}(j)\, \bar{V}(j-1)\, (\bar{I} - \bar{U}(j)\, \bar{k}(j))^T = 0$$

$$-\bar{k}(j)\, \bar{V}(j-1) + \bar{k}(j)\, \bar{V}(j-1)\, \bar{k}(j)^T\, \bar{U}(j)^T = 0$$

giving

$$\bar{U}(j)^T = \frac{\bar{k}(j)\, \bar{V}(j-1)}{\bar{k}(j)\, \bar{V}(j-1)\, \bar{k}(j)^T}$$

Taking the transpose of both sides gives

$$\bar{U}(j) = \frac{\bar{V}(j-1)\, \bar{k}(j)^T}{\bar{k}(j)\, \bar{V}(j-1)\, \bar{k}(j)^T}$$

Where $\bar{V}(j) = \bar{M}(U)\, \bar{V}(j-1)\, \bar{M}(U)^T$ D-17

It can be shown * that equation D-17 may be manipulated to the form

$$\bar{V}(j) = (\bar{I} - \bar{U}(j)\, \bar{k}(j))\, \bar{V}(j-1) \qquad \text{D-18}$$

* Pekar, P.P., Jr., "Adaptive Forecasting of Strategic Turning Points", AACE Bulletin, Vol. 18, No. 2, April 1976, p.38.

The system of equations is now

$$\bar{U}(j) = \frac{\bar{V}(j-1)\ \bar{k}(j)^T}{\bar{k}(j)\ \bar{V}(j-1)\ \bar{k}(j)^T} \qquad \text{and}$$

$$\bar{V}(j) = (\bar{I} - \bar{U}(j)\ \bar{k}(j))\ \bar{V}(j-1).$$

From these two equations it can be shown * that

$$u(i,j) = - \frac{v(i,o)}{\sum_{L-j}^{N} v(L,0)} \qquad \text{D-19}$$

RAM I is therefore composed of the equations:

$$b(i,j) = b(i,j-1) + u(i,j)\ (a(j) - f(j,j-1) \qquad \text{D-20}$$

Where $j \leq i \leq N$

and $$f(i,j) = a(j) + \sum_{L=j}^{i-1} b(L,j) \qquad \text{D-21}$$

Where $j+1 \leq i \leq N+1$

with $$u(i,j) = - \frac{v(i,o)}{\sum_{L-j}^{N} v(L,0)} \qquad \text{D-22}$$

D-1.1 EXAMPLE OF USE OF RAM I

The convenient way to illustrate the use of RAM I is by way of an example (adapted from Pekar (66) .

Suppose table D-1 below describes the organisational plan for a hypothetical project with the planned values, (in this case Rands) and associated uncertainty measures (v(i,o)'s). Figure 0-1 is a plot of these values.

Pekar, P.P., Jr., "In Search of the Uncertainty and Complexity that Impact Strategic Organisational Plans - A Modelling Approach", Unpublished Doctoral Thesis, Illinois Institute of Technology, 1974.

Period	Planned Values R 000 000's		Uncertainty R 000 000	
1	p(1,0)	= 5	V(1,0)	= 1,25
2	P(7,0)	= 10	V(2,0)	= 2,00
3	p(3,0)	= 7	V(3,0)	= 3,00
4	p(4,0)	= 15	V(4,0)	= 1,67
5	p(5,0)	= 3	V(5,0)	= 5,00
Totals		40		12,92

TABLE D-1 : PLAN FOR MYPOTHETICAL PROJECT

The planned slopes are then given by

b(1,0) = p(2,0) - p(1,0) = 5
b(2,0) = p(3,0) - p(2,0) = - 3
b(3,0) = p(4,0) - p(3,0) = 8
b(4,0) = p(5,0) - p(4,0) = -12
b(5,0) = p(6,0) - p(5,0) = - 3 (p(6,0) = 0 by definition)

Suppose the project has now begun and the first reported expenditure is R8 000 000.

In the terminology of this section, this means that at stage j=1, a(1) = 8. We now use RAM I to forecast the expenditures for periods j=2 to 6.

The first step is to calculate the weighting factors, u(i,j)'s. This is done by dividing each uncertainty by the total uncertainty thus (recall equation D-19):

u(1,1) = - 1,25/12,92 = - 0,0968
u(2,1) = - 2,00/12,92 = - 0,1548
u(3,1) = - 3,00/12,92 = - 0,2322
u(4,1) = - 1,67/12,92 = - 0,1293
u(5,1) = - 5,00/12,92 = - 0,3870
TOTAL = - 1,0000

The forecasted slopes are then determined using equation D-20 thus:

$$b(1,1) = 5 - 0{,}0968\,(8-5) = 4{,}7096$$
$$b(2,1) = -3 - 0{,}1548\,(8-5) = -3{,}4644$$
$$b(3,1) = 8 - 0{,}2322\,(8-5) = 7{,}3034$$
$$b(4,1) = -12 - 0{,}1293\,(8-5) = -12{,}3879$$
$$b(5,1) = -3 - 0{,}3870\,(8-5) = -4{,}1610$$

Using equation D-21 the actual forecasted values (f(i,j)) can then be found:

$$a(1) = 8$$
$$f(2,1) = 8 + 4{,}7096 = 12{,}7096$$
$$f(3,1) = 12{,}906 - 3{,}4644 = 9{,}2452$$
$$f(4,1) = 9{,}2452 + 7{,}3034 = 16{,}5486$$
$$f(5,1) = 16{,}5486 - 12{,}3879 = 4{,}1607$$

Check : f(5,1) - b(5,1) = 0, hence no arithmetical errors within computational accuracy limits.

The new forecasted total of expenditures to the end of the project is given by the total of the f(1,1)'s and is R50,6645 million (as compared to the planned or budgeted total of R40 million).

The above information has been plotted on figure D-1. Suppose now that a(2) was reported to be R12 million. The procedure would be repeated, and the results would be as shown in table D-2. These results have also been plotted on figure D-1.

Period (1)	u(1,2)	b(i,2)	f(i,2) or a(i) R 000 000
1			8
2	- 0,1714	- 3,3429	12
3	- 0,2571	7,4857	8,6571
4	- 0,1429	- 12,2857	16,1429
5	- 0,4286	- 3,8571	3,8571
		Total Forecasted	48,6600

TABLE D-2 : TABULATED RESULTS FOR a(2) = 12

D-2 RAM II and RAM III

The following terms are defined:

= the future period being forecasted.

j = the present reporting period under analysis

N = the total number of planned periods comprising the project.

p(i,o) = the planned values as for RAM I.

a(j) = the actual reported values as for RAM I.

f(i,j) = the forecasted values as for RAM I.

Note that f(i,o) = p(i,o)

$P(o) = \sum_{1=1}^{N} p(i,o)$ i.e. the total budgeted constraint in terms of cashflow, manhours or physical completion.

P(j) = the revised total constraint at period j. It is expressed mathematically by

$$P(j) = a(1) + a(2) + ... + a(j) + \sum_{i=j+1}^{N} f(i,j)$$

P(j-1) = the previous total constraint at period j. It is expressed mathematically by

$$P(j-1 = a(1) + a(2) + ... + a(j-1) + \sum_{i=j}^{N} f(i,j-1)$$

Z(i,j) = the uncertainty measure associated with each (i,j), where a large Z(i,j) represents a small uncertainty. Referring to the RAM I definitions,

$$Z(i,j) = \frac{1}{v(i,o)} \text{ for any } j.$$

We require a general forecasting equation which will predict a new value for the expenditure in each future period given the previous forecast, and subject to the overall project constraint in terms of budgeted expenditure.

Such an equation should therefore have the general form

$$f(i,j) = f(i,j-1) + \phi(i)\,(a(j) - f(j,j-1)) \qquad \text{D-23}$$

Where $\phi(i)$ is the smoothing constant which will be updated each reporting period j, for values of $i > j$.

In order to minimise the modifications to previous estimates, $\phi(i)$ must satisfy the relation

$$\sum_{L=j+1}^{N} Z(i.j)\,(f(i,j) - f(i,j-1))^2 \text{ is minimised}$$

Where $\sum_{L=j+1}^{N} (f(i,j) = F(j)$ D-24

Using a LaGrange Multiplier we construct a function M such that

$$M = \frac{1}{2} \sum_{i=j+1}^{N} Z(i,j)\,(f(i,j) - f(i,j-1))^2 + \lambda \sum_{i=j+1}^{N} f(i,j) - F(j)) \qquad \text{D-25}$$

From equation D-23 we can see that

$$(f(i,j) - f(i,j-1))^2 = \phi(i)^2\,(a(j) - f(j,j-1))^2 \qquad \text{D-26}$$

Summating both sides of D-20 from i = j+1 to N gives

$$\sum_{i=j+1}^{N} f(i,j) = \sum_{i=j+1}^{N} (f(i,j-1) + \phi(i)\,(a(j) - f(j,j-1)) \qquad \text{D-27}$$

Substituting D-27 and D-26 into D-25 gives

$$M = \frac{1}{2} \sum_{i=j+1}^{N} Z(i,j)\,\phi(i)^2\,(a(j) - f(j,j-1))^2$$

$$+ \sum_{i=j+1}^{N} (f(i,j-1) + \phi(i)\,(a(j) - f(j,j-1))) - F(j))$$

Taking the partial derivative of M with respect to $\phi(i)$ and setting equal to zero,

$$\frac{\partial M}{\partial \phi(i)} = Z(i,j)\,\phi(i)\,(a(j) - f(j,j-1))^2$$

$$+ \lambda\,(a(j) - f(j,j-1)) = 0 \qquad \text{D-28}$$

Similarly,

$$\frac{\partial M}{\partial \lambda} = \sum_{i=j+1}^{N} f(i,j) - F(j) = 0 \qquad \text{D-29}$$

Solving for $\phi(i)$ in equation D-28 gives

$$\phi(i) = - \frac{\lambda}{Z(i,j)} \cdot \left(\frac{1}{a(j) - f(j,j-1)} \right) \qquad \text{D-30}$$

Substituting this into equation D-23, gives

$$f(i,j) = f(i,j-1) - \frac{\lambda}{Z(i,j)} \qquad \text{D-31}$$

Summating both sides of equation D-31 we obtain

$$\sum_{i=j+1}^{N} f(i,j) = \sum_{i=j+1}^{N} f(i,j-1) - \lambda \sum_{i=j+1}^{N} \frac{1}{Z(i,j)} \qquad \text{D-32}$$

Using definition D-24,

$$F(j) = \sum_{i=j+1}^{N} f(i,j-1) - \sum_{i=j+1}^{N} \frac{1}{Z(i,j)} \qquad \text{D-33}$$

Solving for λ,

$$\lambda = \frac{\sum_{i=j+1}^{N} f(i,j-1) - F(j)}{\sum_{i=j+1}^{N} \frac{1}{z(i,j)}} \qquad \text{D-34}$$

Substituting equation D-34 into equation D-31,

$$f(i,j) = f(i,j-1) + \phi(i) \left(\sum_{i=j+1}^{N} f(i,j-1) - F(j) \right) \qquad \text{D-35}$$

Where $$\phi(i) = - \frac{1}{z(i,j) \sum_{i=j+1}^{N} \frac{1}{z(i,j)}} \qquad \text{D-36}$$

Equations D-35 and D-36 are our desired forecasting equations.

It can be shown * that they may be simplified to

$$f(i,j) = f(i,j-1) + \phi(i) \left(P(j-1) - P(j) - f(j,j-1) + a(j) \right) \qquad \text{D-37}$$

For $j+1 \leq i \leq N$

* Pekar, P.P., Jr., "In Search of the Uncertainty and Complexity that Impact Strategic Organisational Plans - A Modelling Approach", Unpublished Doctoral Theis, Illinois Institute of Technology, 1974.

$$\text{and} \quad \phi(i) = -\frac{1}{z(i,j)\ \sum_{i=j+1}^{N} \frac{1}{z(i,j)}} \qquad \text{D-38}$$

For $j+1 \leq i \leq N$

These are the RAM II and RAM III equations. The distinction between RAM II and RAM III is best explained by the example which follows.

D-2.1 EXAMPLE OF USE OF RAM II AND III

The use of RAM II and RAM III is best explained by way of an example. Using the same example as for RAM I, the project plan is reproduced below in table D-3. Note that the same uncertainty measures have been used with the conversion that

$$Z(i,j) = \frac{1}{v(i,j)}$$

Period i	Planned Exenditure p(i,o)	Uncertainty Z(i,o)
1	5	0,8
2	10.	0,5
3	7	0,33
4	15	0,6
5	3	0,2

TABLE D-3 : ORIGINAL PROJECT PLAN

Using the RAM II, the weighting factors are given by equation D-36:

$$\phi(i) = - \frac{1}{Z(i,j) \sum_{i=2}^{N} \frac{1}{Z(i,j)}}$$

Hence $\phi(2) = (-1)/(0,5) \left(\frac{1}{0,5} + \frac{1}{0,33} + \frac{1}{0,6} + \frac{1}{0,2} \right)$

$= - 0,1714$

Similarly, $\phi(3) = - 0,25714$
$\phi(4) = - 0,1428$
$\phi(5) = - 0,4286$

Then, at j = 1,

a(1) = 8 and using equation D-35,

$f(2,1) = f(2,0) + \phi(2) (P(o) - P(1) + a(1) - f(1,0))$
$f(3,1) = f(3,0) + \phi(3) (P(o) - P(1) + a(1) - f(1,0))$
$f(4,1) = f(4,0) + \phi(4) (P(o) - P(1) + a(1) - f(1,0))$
$f(5,1) = f(5,0) + \phi(5) (P(o) - P(1) + a(1) - f(1,0))$

Let us assume that the original budget constraint is still valid. Then P(1) = 40, and P(o) = 40.

Then	a(1)	= 8
	f(2,1) = 10 - 0,1714 (40 - 40 + 8 - 5)	= 9,4857
	f(3,1) = 7 - 0,25714 (40 - 40 + 8 - 5)	= 6,22857
	f(4,1) = 15 - 0,1428 (40 - 40 + 8 - 5)	= 14,5714
	f(5,1) = 3 - 0,4268 (40 - 40 + 8 - 5)	= 1,7143
	TOTAL	= 40 million

Now at j=2, a(2) = 12 million. Management now reacts by obtaining additional funding so that P(2) = 44 million. Using RAM III, the first step, once again, is to determine the weighting factors. These are

ø (3) = - 0,3103
ø (4) = - 0,1724
and ø(5)= - 0,5172

Hence, using the forecasting equation D-35 once again,

a(1) = 8
a(2) = 12
f(3,2) = f(3,1) + 0(3) (P(1) - P(2) + a(2) - f(2,1))
f(4,2) = f(4,1) + 0(4) (P(1) - P(2) + a(2) - f(2,1))
f(5,2) = f(5,1) + 0(5) (P(1) - P(2) + a(2) - f(2,1))

Substituting known values,

a(1) = 8
a(2) = 12
f(3,2) = 6,22857 - 0,3103 (40 - 44 + 12 - 9,4857) = 6,6897
f(4,2) = 14,5714 - 0,1724 (40 - 44 + 12 - 9,4857) = 14,8276
f(5,2) = 1,7143 - 0,5172 (40 - 44 + 12 - 9,4857) = 2,4828
TOTAL = 44 million

APPENDIX E

E -1 INDUSTRIAL OPINION SURVEY

A number of formal and informal interviews were held with the persons listed in section E-2. In section E-3 the Specification Document of a typical Progress Report is reproduced. This is intended to give some idea of what a typical progress report entails. This series of interviews was held with the following objectives in mind:

i) to give this research some direction by discussing current thoughts on the topic being studied with people who were practically involved with the subject; and

ii) to determine whether or not there was indeed a need for an objective forecasting technique.

It should be emphasised that what follows is by force of circumstances a qualitative description rather than a quantitative analysis of the results of these interviews.

It was found that in general most people were unaware of the distinction between a subjective and an objective forecasting method. Most were happy with the systems currently being used (see section E-3) and did not feel there was any *need* for the development of an alternative. Of those who did understand the general idea of what was proposed to *be* done during the course of this research, most were reasonably enthusiastic but felt that there was a danger in putting too much faith in a purely analytical technique which was entirely dependant on the information with which it was supplied.

It may be concluded from the above that a need for an objective technique does exist in Industry. Mowever, such a technique would have to be proved to be reliable and useful before it gained a measure of acceptance.

E-2 PERSONS INTERVIEWED

Mr J. Bigham	Consulting Mechanical and Electrical Engineer,Projects and Technical; General Mining Union Corporation Ltd.
Mr J.A. de Beer	Principal Engineer; Electricity Supply Commission
Mr J.C. Fritz	Chief Executive, Gold and Uranium; General Mining Union Corporation Ltd.
Mr B. Hart	Pricipal Engineer; Electricity Supply Commission
Mr W. Jardine	Chief Projects Engineer; General Mining Union Corporation
Mr R. Knott	Cost Engineering Manager; Engineering Management Services
Mr T. Kruger	Deputy Director - Maintenance; South African Airways
Mr C. Loxley-Ford	Senior Consultant - Project Management and Control Group; Control Data Corporation
Mr L. Myers	Manager - Cost and Scheduling; Fluor Ltd
Mr J. Schmidt	Manager - Cost and Scheduling; Fluor - Genrec Ltd.
Mr H.A. Smith	Chief Executive - Investments and Administration Division; General Mining Union Corporation Ltd.
Mr D.R. Snaddon	Lecturer (Department of Business Economics); University of Witwatersrand
Mr C.J. Sutton	Chief Cost Engineer; General Mining Union Corporation Ltd.
Mr F.T. Vorster	Group Senior Manager; General Mining Union Corporation Ltd.
Mr A.G. Woods	Assistant Chief Cost Engineer; General Mining Union Corporation Ltd.

E -3 TYPICAL PROGRESS REPORT SPECIFICATION

A typical progress report specification document is reproduced in the following pages. The following explanatory notes are relevant:

E-3.1 Total Project Cost Summary

Authorised Budget	- The original budget vote.
Authorised Scope Changes	- Voted changes to the budget arising from changes in scope.
Current Budget	- Authorised budget + authorised scope changes.
Current Forecast	- An expert-subjective figure of what the final cost will be.
Commitments	- The monetary value of all orders placed and contracts awarded.
Variance	- Current forecast - Current budget.
Costs	- Payments made.
Retentions	- Money withheld from a contractor pending the satisfactory completion of the contract.

PROJECT NAME

MONTMLY PROGRESS REPORT – NUMBER

DATE (Month, Year)

CUT OFF DATE : Day, Month, Year

APPROVED FOR ISSUE ON : Day, Month, Year

INDEX PACE

I	Distribution list
II	Narrative
III	Total Project Cost Summary
IV	Project Commitment and Cash Flow
V	Construction Progress Report
VI	Engineering Progress Report
VII	Project Key Dates
VIII	Progress Photographs

I.

DISTRIBUTION LIST

Messrs .....

.....

II

THE NARRATIVE

This narrative will be structured according to the following areas :

1-- - Land Purchase and Site Development.
15- - Housing
2-- - Shaft - Mining Responsibility.
3-- - Shaft - Engineering Responsibility
4-- - Milling Plant
5-- - Uranium Plant
6-- - Gold Plant
7— - Process Support Services
8 — — Non-Process Support Services
9-- — Project Services

The first part of the narrative will briefly describe the work done during the month in each area.

The second part will discuss the items of major concern in each area as follows:

Problem

A terse statement of the problem(s) will be made.

Proposed Action

1 The proposed action to solve the above problem(s) will be set out.

The third part will specifically highlight deviations from plan under the following headings:

A. COST VARIANCES

A full explanation will be given for significant, cost variances that appear on the TOTAL PROJECT COST SUMMARY (see III) and where necessary references will be made to other parts of this report for reasons.

B. KEY DATES

A difference of two weeks will be considered as significant.

C. CONSTRUCTION PROGRAM

Significant differences between actual and program or forecast area completion percentage will be fully explained.

D. ENGINEERING PROGRAM

Mention will be made of the good or bad impact on the job resulting from the sequences or rates at which drawings, specifications, requisitions etc. have been or will be released for the project.

E. PLANT AND EQUIPMENT DELIVERIES

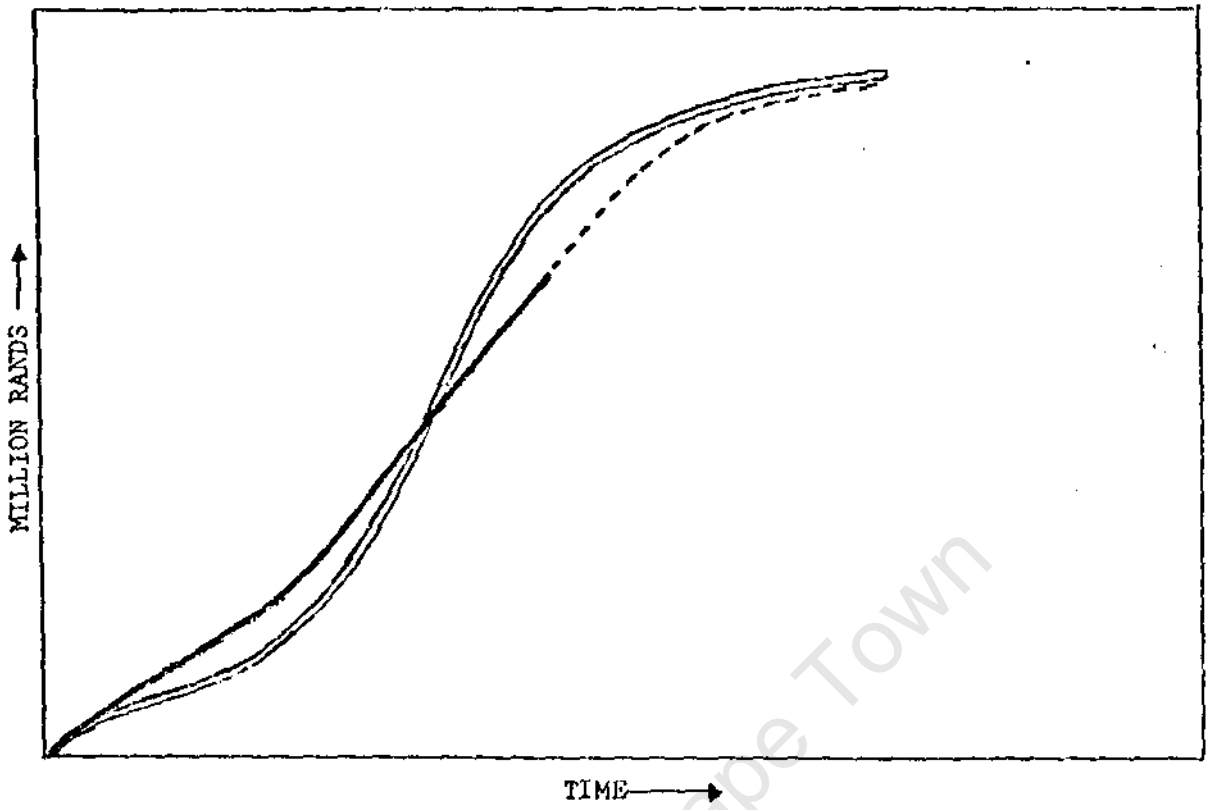
Comments will be passed about the effect of deliveries upon progress. Highlighted will be whether the things received were the things needed and which things should be expedited to improve progress or save money in installation.

ALL COSTS IN R 000'S

CUT OFF DATE : MONTH, DAY, YEAR.
RUN DATE :
BASE DATE :
MONTHLY REPORT

AREA	DESCRIPTION	AUTHOR. BUDGET	AUTHOR. SCOPE CHANGES	CURRENT BUDGET	CURRENT FORECAST	COMMITMENTS			VARIANCE	COSTS	
						THIS MNTH.	TO DATE	AT BASE		THIS MNTH.	TO DATE
1-	LAND PURCHASE AND SITE DEVELOPMENT										
1S	HOUSING										
2-	SHAFT - MINING RESPONSIBILITY										
3-	SHAFT - ENGINEERING RESPONSIBILITY										
4-	MILLING PLANT										
5-	URANIUM PLANT										
6-	GOLD PLANT										
7-	PROCESS SUPPORT SERVICES										
8-	NON PROCESS SUPPORT SERVICES										
9-	PROJECT SERVICES										
	SUB TOTAL										
	CONTINGENCY										
	ESCALATION										
	TOTAL										
	TOTAL BUDGET ESCALATION TO MONTH END.....									LESS RETENSIONS	
										PAYMENTS TO MONTH END.....	
	COMMITMENT ESCALATION										
	COST ESCALATION									ESTIMATED FUTURE COMMITMENTS	
	CURRENCY ESCALATION									AT BASE DATE	
	TOTAL ACTUAL ESCALATION TO MONTH END.....										

PROJECT COMMITMENT



LEGEND

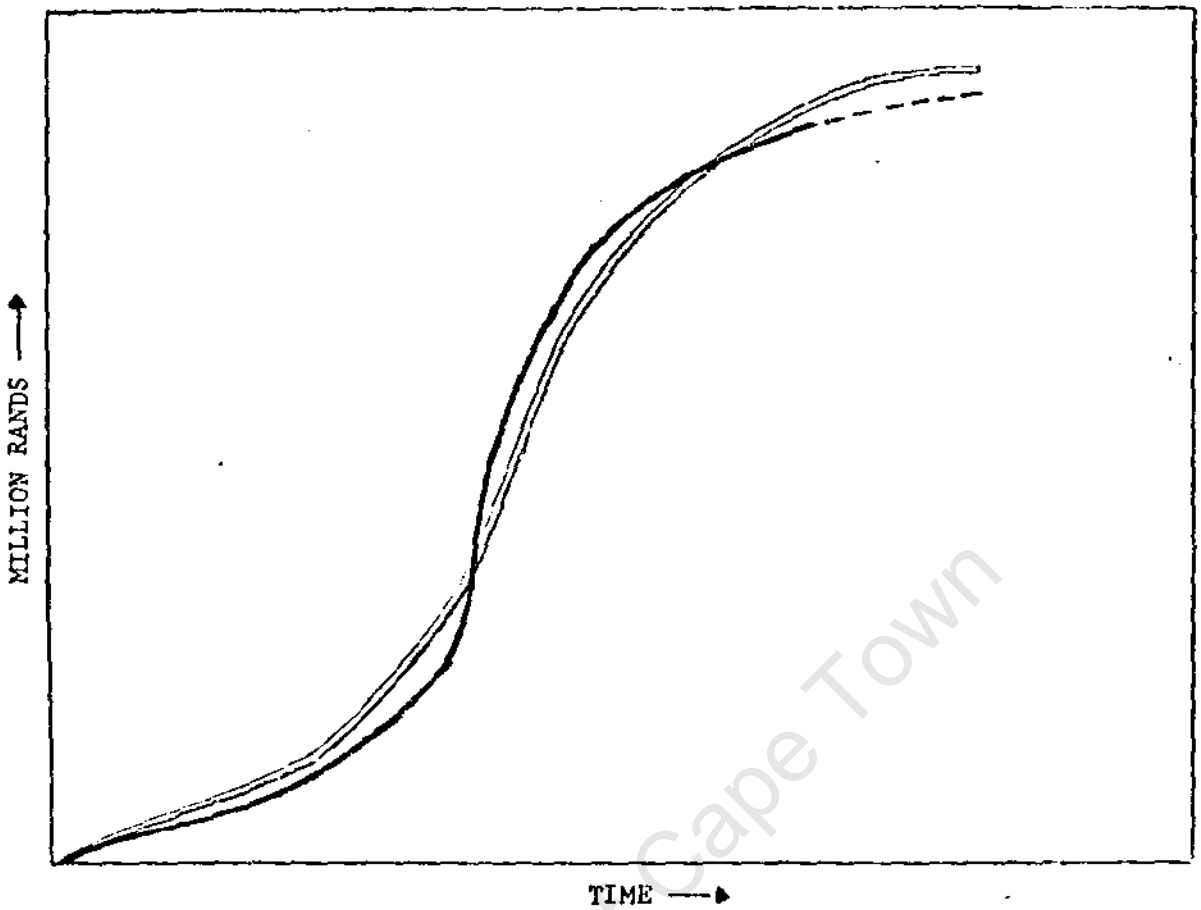
Budget Including Contingency

Actual to Date Including Escalation and Currency Variation.

Forecast (at month, year)

IV

PROJECT CASH FLOW



LEGEND

Budget Including Contingency

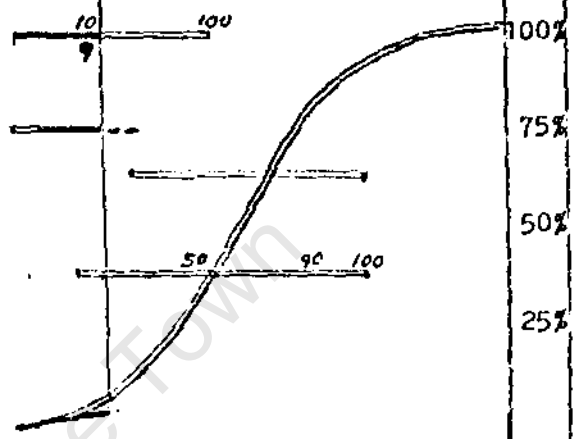
Actual to Date Including Escalation and Currency Variation.

Forecast (at month, year)

V

CONSTRUCTION PROGRESS

Item Description	% of Job	Cum Prog	TIME →
Site Development	22.1	1.5	
.....	-	-	
.....	-	-	
.....	-	-	
.....	-	-	
Gold Plant	17.0	-	
.....	-	-	
.....	-	-	
.....	-	-	
TOTAL	100	1.5	
% Project Completion	Program		4%
	Actual	0%	1.5% 100%



Legend

Original Program | Actual Program | Current Forecast

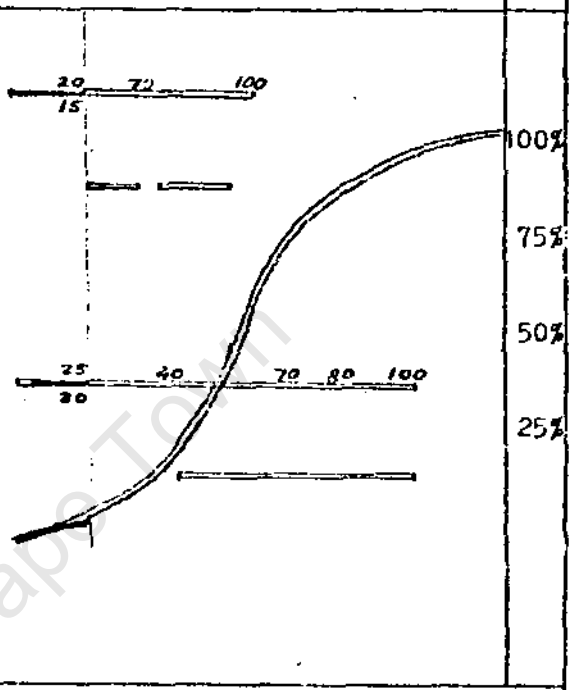
10 ← Figure Denotes programmed progress (above line)

9 ← Actual/Forecast progress (below line)

VT

ENGINEERING PROGRESS

Item Description	% of Job	Cum Prog	TIME →
Process			
Support Facilities	6.0	1.0	
.....	-	-	
.....	-	-	
.....	-	-	
.....	-	-	
.....	-	-	
Gold Plant	12.0	4.0	
.....	-	-	
.....	-	-	
.....	-	-	
.....	-	-	
TOTAL	100	5.0	
% Project Completion	Program.		8%
	Actual.	0%	5% 100%



Legend

Original Program | Actual Program | Current Forecast

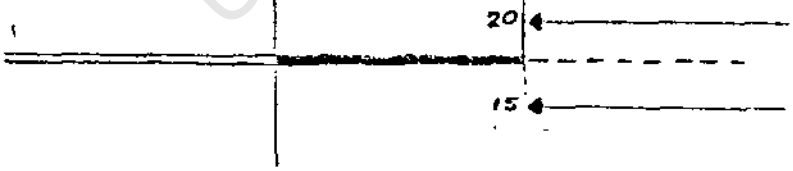


Figure Denotes programmed progress (above line)

Actual/Forecast progress (below line)

VII

PROJECT KEY DATES

Key dates for all important events will be presented in the following format:

Description	Start Date	Completion Dates		
		Target	Forecast	Actual

PROGRESS PHOTOGRAPHS

The pictures are intended to show construction progress. Photographs will be taken from the same stations and preference will be *for* horizontal format photographs wherever possible.

APPENDIX F

DEVELOPMENT OF TME GENERALISED RESOURCE APPRAISEMENT MODEL

F-1 NOMENCLATURE

See Figure F-1.

k = the update number; in general k can have any interger value greater than zero; the special case when k-1 = 0 refers to the original budget;

I(k) = the actual physical percent completion (PPG) reported during update number k;

j = the value of PPC we wish to forecast to;

m = the interval of PPC between the successive values of j; hence j can only take on ordered values given by j = nm, where n 4100/m;

$F_c(k,j)$* = the forecast made during update number k, of the monetary expenditure to be made in the interval of PPC from j-m to j; in the case where I(k) is not a j, i.e. when j <I(k) < j+m for any j, $F_c(k,I(k))$ shall be the forecasted expenditure from I(k) to the next value of j, defined as J(k), i.e.

J(k) - m < I(k), J(k) = nm;

Gc(k,j) = the forecasted gradient of the ordered interval of PPC from j to j + m;

Gca(k-1) = the actual gradient of the cost for the interval of PPC from I(k-1) to I(k);

Gca(k) = the actual relative change in gradient for cost in period k;

Cca(k) Gca(k-1)/Gc(k-1, I(k-1));

$C_cf(k)$ = the change in the cost gradients forecasted during period k, for all j p. 1(k);

$S_c(k)$ = the smoothing constant used during update number k to forecast $C_cf(k)$;

Wherever a subscript 'c' appears it may be replaced by the subscript 't' to refer to time.

$A_c(I(k))$ = the actual monetary expenditure reported during update period k, for the PPC interval I(k-1) to I(k);

$U_c(k,j)$ = the certainty factor calculated during period k, of the cost at the ordered interval of PPC from j-m to j, and I(k) to J(k);

T_c = tracking signal, cost;

E_c = the error (unsmoothed) in any update number, k;

$E_{C(k)}$ = the smoothed error, cost, in update number k;

Eca(k) = the absolute smoothed error, cost, in update number k;

Pc(k) = the cost of the work in progress during update number k;

Qc(k,J) the cost of the work which, it is forecasted in update number k, must be done to increase the PPC from I(k) to j (includes work in-progress);

Ri_c= 1- the percent unit contingency associated with the cost of in-progress work;

R2c = 1- the per unit contingency associated with the cost of work planned but not yet commenced;

Dic = maximum possible certainty, cost;

$D2_\Theta$= certainty gradient, cost;

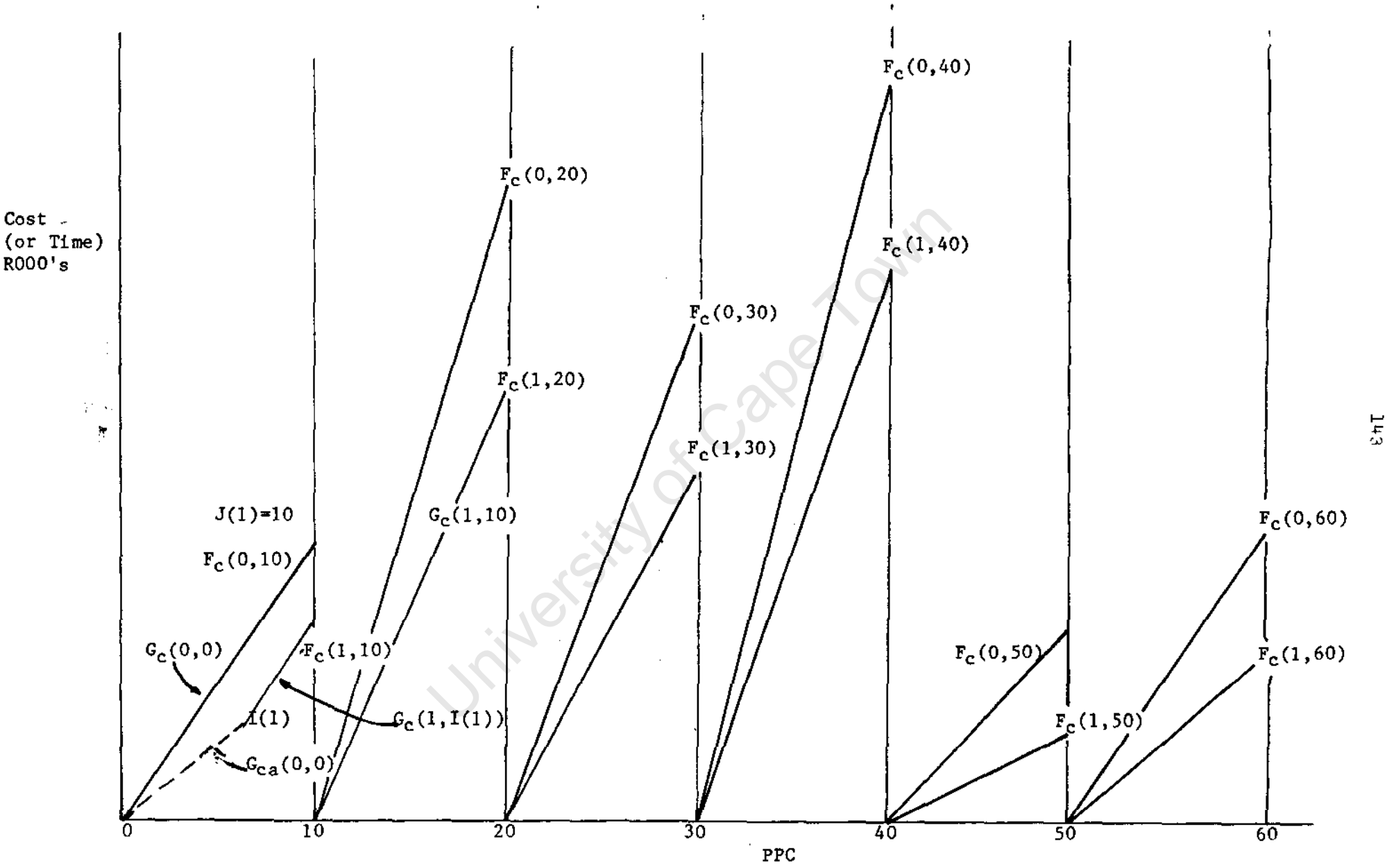


FIG. F-1 : FIGURE ILLUSTRATING GRAM NOMENCLATURE

F-2 DERIVATIONS

It should be noted that GRAM is a calculation procedure rather than the expression of a single equation. The calculation process consists of six steps; this derivation considers each step in turn with the necessary explanation for that step.

STEP 1 - CALGULATE THE ACTUAL RELATIVE CHANGE IN TME GRADIENT

It will be seen from figure F-1 that the reported values of PPC, I(k), need not necessarily coincide with the ordered values of PPC, the j's. The actual reported gradient will therefore be the actual cost reported divided by the PPC interval from I(k-1) to I(k), i.e.

$$G_{ca}\,(I(k-1)) = A_c.\,(k)/(I(k) - I(k-1)) \qquad \text{F-1}$$

In order to compare the actual and forecasted gradients they need to be calculated on the same basis. Now the forecasted cost for the interval from 1(k-1) to I(k) will be given by

$$\text{Cost from } I(k-1) \text{ to } I(k) = \sum_{p=J(k-1)}^{J(k)-m} F_c(k-1,p) + \frac{F_c(k-1,\,J(k))(I(k)+m-J(k))}{m}$$

Hence the forecasted gradient from I(k-1) to 1(k), G_c(k-1, I(k-l)), will be given by

$$G_c(k-1,I(k-1)) = \frac{\sum_{p=J(k-1)}^{J(k)-m} F_c(k-1,p)+F_c(k-1,J(k))(I(k)+m-J(k))}{m(I(k) - I(k-1))} \qquad \text{F-2}$$

The relative error of the gradient, or the relative change from forecasted to the actual gradient, $C_{ca(k)}$, is threfore given by

$$C_{ca}\,(k) = G_{ca}\,(I(k-1))/G_c(k-1,\,I(k-1)) \qquad \text{F-3}$$

Where $G_{ca}(I(k-1))$ and $G_{c}(k-1, I(k-1))$ are calculated from equations F-1 and F-2 respectively

STEP 2 - CALCULATE TME CERTAINTY FACTORS

The approach outlined in Chapter Three is applicable to both time and cost. In this section an objective way of calculating the certainty factor for cost is outlined. This method may be suitable to certain projects. In this method the certainty factor is the weighted average of unity minus the relative contingency of in-progress work and outstanding work. By relative contingency is meant the contingency for any ordered interval of j, divided by the total forecasted expenditure in that interval. In general this figure will vary from 5% to 40% for cost depending on the level of design and how definitive the budget capital estimate was. Mence R_{2c} varies from 0,60 to 0,95; on the other hand work in-progress has a significantly smaller value of contingency, typically between 1% and 5%. Hence R_{1c} varies from 0,95 to 0,99. A direct means of determining P(k) is to consider work in progress as all the money which has been committed minus the money which has been paid out at update number k.

By the same token Q(k,j) may be determined objectively as the forecasted commitments to make the project j per cent physically complete, from I(k) in update number k.

Now the weighted average of the contingencies at any point, or the certainty factor $U_c(k,j)$ will, by the above discussion be given by

$$U_c(k,j) = \frac{\text{Cost of work in-progress } R_{1c} + \text{Cost of work outstanding } R_{2c}}{\text{Cost of work in-progress + Cost of work outstanding}}$$

$$= \frac{P_c(k)R_{1c} + (Q_c(k,j) - P_c(k))R_{2c}}{Q_c(k,j)}$$

$$= \frac{P_c(k)(R_{1c} - R_{2c}) + Q_c(k,j)R_{2c}}{Q_c(k,j)} \qquad \text{F-4}$$

Where $J(k) \leq j \leq 100$

An equivalent formulation for time is not possible since it is not meaningful to speak of "in-progress time" - jobs can run concurrently. Nonetheless the assumption is made here that the certainty of the duration of jobs decreases as the forecasting horizon increases. Furthermore it is assumed that the decreasing certainties bear a linear relationship to PPC, i.e. the forecasting horizon here is with respect to PPC, and not time. This may be expressed as:

$$U_t(k,j) = D_1 - D_2(j-J(k)) \qquad \text{F-5}$$

The constants D_I and D_2 warrant some attention.

D_I is the certainty which the reporting period immediately after I(k), i.e. J(k), will be given. Values between 0,95 and 0,98 would seem reasonable.

D_2 is the gradient (certainty per PPC), and therefore controls how rapidly the certainty decreases. At the start of a project, the minimum certainty (i.e. the certainty at the end of the project) would be between 0,75 and 0,80. Using these values, D_2 would take on, under normal conditions, values in the region of 0,0018 to 0,0023 per PPC. Equation F-5 always makes J(k) have a certainty of D_1, and decreases successive values of j according to D_2.

It is worthwhile noting that the approach adopted here for time could also be used for cost. In this case D_I and D_2 are directly dependent on the level of design which has been accomplished when the definitive estimate is carried out.

It is also worth noting that using the certainty factors, either time or cost may be constrained in order to investigate, for example, what would happen to the project cash flow if the project was to be crashed (i.e. speeded up to be completed within a certain time limit irrespective of the cost involved). The opposite is also true where an organisation with severe limits on its resources would wish to determine when the project would end should the resources available to it be minimised.

This flexibility in GRAM is achieved through the incorporation of the certainty factors.

STEP 3 - CALCULATE THE SMOOTHING CONSTANTS

A number of alternatives exist, as discussed in Chapter Two, as to how the smoothing constant should be chosen. As was pointed out in Chapter Two, current literature would tend to indicate that unrestricted, continuously evaluated adaptive smoothing techniques offer computational advantages with little or no loss of forecasting performance. The most simple Trigg and Leach model sets the smoothing constant equal to the modulus of the tracking singal. This is done as follows:

The error, E_{ca}, in update number k is given by the actual change in gradient less the change forecasted in update number k-1, i.e.

$$E_c = C_{ca}(k) - C_{cf}(k-1) \qquad \text{F-6}$$

where $C_{cf}(0)$ is set to an initialising value.

The absolute error, E_{ca} in update number k is given by

$$E_{ca} = \text{modulus } 1\ E_C I \qquad \text{F-7}$$

Then, applying the Trigg and Leach equations from section 3.3.2, the smoothed error in update number k will be

$$E_c(k) = E_c(k-1) + g(E_c - E_c(k-1)) \qquad \text{F-8}$$

Similarly the absolute smoothed error will be given by

$$E_{ca}(k) = Eca(k-1) \quad g(Eca \; \Xi ca(k-1)) \qquad \text{F-9}$$

The smoothing constant is then given by

$$S_c(k) = \text{Modulus of the Tracking Signal}$$

$$\text{i.e.} \quad S_c(k) = \text{Modulus} \left| \frac{E_c(k)}{E_{ca}(k)} \right| \qquad \text{F-10}$$

Note once again that $E_c(0)$ and $E_{ca}(0)$ need to be assigned some initialising value.

STEP 4 - FORECAST THE RELATIVE CHANGE IN GRADIENT

Recall the general exponential smoothing equation from Chapter Two (do not confuse the nomenclature):

$$S_t = S_{t-1} + a(d_t - S_{t-1})$$

Applying the variables relevant to forecasting the relative change in cost gradient,

$$C_{cf}(k) = C_{cf}(k-1) - S_c(k)\,(C_{ca}(k) - C_{cf}(k-1)) \qquad \text{F-11}$$

Note that $C_{cf}(0)$ would have to be assigned some initialising value.

STEP 5 - CALCULATE THE GRADIENTS

The equation calculating the gradients must satisfy the following conditions:

a) If the certainty is unity, the new gradient must equal the old gradient.

b) If the certainty is zero, the new gradient must equal the old gradient multiplied by the forecasted change in gradient.

These conditions are met by the following expression:

$$G_c(k,j) = G_c(k-1,j)\ U_c(k,j) + G_c(k-1,j)(1-U_c(k,j))\ C_f(k) \qquad \text{F-12}$$

STEP 6 - CALCULATE THE FORECASTED PARAMETERS

The forecasted parameters may be determined simply by multiplying the gradients obtained in Step 5 by the appropriate interval of PPC.

$$F_c(k,j) = G_c(k,j)m \quad \text{if } j \geq J(k)+m \text{ and } j \leq 100 \qquad \text{F-13}$$

$$\text{and } F_c(k,j) = G_c(k,j)(J(k) - I(k)) \qquad \text{F-14}$$

When $I(k) < j \leq I(k)+m$

and $j \leq 100$

APPENDIX G

LISTING OF COMPUTER PROGRAM AND SAMPLE PRINTOUT REPORT WITH EXPLANATORY COMMENTS

G-1 LISTING OF COMPUTER PROGRAM

```
$ LIST OF FILE            GRAM

C
C***************GENERALISED RESOURCE APPRAISEMENT MODEL**********************
C     THIS PROGRAM FORECASTS THE TIME AND COST REQUIRED TO COMPLETE A PRO-
C     JECT USING THE GENERALISED RESOURCE APPRAISEMENT MODEL. THE FOLLOWING
C     PARAMETERS ARE USED IN THE PROGRAM (THE PARAMETERS DEFINED ARE FOR
C     COST. THE EQUIVALENT TIME PARAMETERS HAVE THE LETTER T INSTEAD OF C):
C       K5=THE REPORTING PERIOD IN WHICH THE MOST RECENT PROJECT REVIEW
C            WAS MADE. THIS WOULD NORMALLY ENTAIL A VOTED CHANGE IN THE
C            AUTHORISED BUDGET.
C       P1=THE MOST RECENT UPDATE OF PPC (PHYSICAL PERCENT COMPLETION).
C       K1=THE PRESENT UPDATE NUMBER+1
C       ACTC(J)=THE ACTUAL COST REPORTED FOR THE INTERVAL OF PPC ENDING
C            WITH J.
C       P2=THE ORDERED VALUE OF PPC JUST GREATER THAN P1.
C       K2=THE SPACING BETWEEN THE ORDERED VALUES OF PPC.
C       UC=THE CERTAINTY FACTOR AT A CERTAIN VALUE OF PPC
C       D1C=THE CERTAINTY ASSOCIATED WITH P2.
C       D2C=THE RATE AT WHICH THE CERTAINTY DECREASES WITHINCREASING PPC.
C       CGRADC(K)=THE FORECASTED RELATIVE CHANGE IN GRADIENT IN UPDATE K.
C       P3=THE P1 USED IN THE PREVIOUS UPDATE.
C       P4=THE P2 USED IN THE PREVIOUS UPDATE.
C       P5=P4-K2
C       P6=P2-K2
C       GRADAC=THE ACTUAL GRADIENT.
C       TOTGC=TOTAL COMMITMENTS USED TO FIND THE BUDGET GRADIENT GRADC1.
C       COST(I,J)=THE COST FORECASTED IN UPDATE I, FOR THE INTERVAL OF PPC
C            FROM J-K2 TO J.
C       CGRAD1=THE ACTUAL RELATIVE CHANGE IN GRADIENT.
C       ENC=THE NEW ERROR (UNSMOOTHED).
C       ENCA=THE NEW ABSOLUTE UNSMOOTHED ERROR.
C       SC=THE SMOOTHING CONSTANT.
C       EOC=THE OLD ERROR.
C       EOCA=THE OLD ABSOLUTE ERROR.
C       GRADC(K)=THE FORECASTED GRADIENT IN UPDATE K.
C       A1=THE PPC.
C       A2=THE BUDGET TIME.
C       A3=THE FORECASTED OR ACTUAL TIME.
C       A4=THE BUDGET COST.
C       A3=THE FORECASTED OR ACTUAL COST.
C       A5=CUMULATIVE BUDGET TIME.
C       A6=CUMULATIVE FORECAST TIME.
C       A7=CUMULATIVE BUDGET COST.
C       A8=CUMULATIVE FORECAST COST.
C       A9=PROGRESSIVE VARIANCE TIME IN DAYS.
C       A10=PER UNIT VARIANCE TIME IN %.
C       A11=PROGRESSIVE VARIANCE COST.
C       A12=PER UNIT VARIANCE COST IN %.
C       A13=CERTAINTY FACTOR TIME.
C       A14=CERTAINTY FACTOR COST.
C       TOTC1=CUMULATIVE TOTAL BUDGET COST.
C       TOTC2=CUMULATIVE TOTAL FORECASTED & REPORTED COST.
C       TOTBC=THE TOTAL COST FOR AN INTERVAL OF PPC.
C       TC1=ACTUAL TOTAL COST TO DATE.
C       TC2=BUDGET TOTAL COST TO DATE.
C       TC3=BUDGET TOTAL COST TO COMPLETION.
C       TC4=FORECAST TOTAL COST TO COMPLETION.
C       TC5=BUDET TOTAL PROJECT.
C       TC6=FORECAST TOTAL PROJECT.
C  FILES:      8=PRINT FILE
C              20=FREE FORMAT FILE CONTAINING BUDGET DATA.
C              24=ELT FILE CONTAINING UPDATE DATA.
C
```

```
TS  LIST OF FILE              GRAM

  C*************************************************************************
  C
  C
        DIMENSION ACTT(100),ACTC(100),UC(100),UT(100),GRAD
       &C(100),COST(50,100),TIME(50,100),GRADT(100),PC(10,100),PT(10,
       &100),CGRADC(50),CGRADT(50)
        DEFINE FILE 8 (APRNTA,,132)
        K5=0.0
        EOT=0.0
        EOC=0.0
        EOCA=0.0
        EOTA=0.0
        G=0.1
 1000   FORMAT()
         READ(20)ACTT,ACTC,UC,UT,COST,TIME,PC,PT,K2,K5
        DO 5000  KILL=1,100
        READ(24,1000)P1,A1,A2,K1
        IF(P1 .GT.  100)GO TO 700
        K1=K1+1
        ACTC(P1)=A2*1000.
        ACTT(P1)=A1
        CGRADC(1)=1.0
         CGRADT(1)=1.0
  C
  C                 DETERMINE P2
         DO 90 J=K2,100,K2
         IF (P1 .LT.  J) GO TO 100
  90     CONTINUE
  100    P2=J
  C
  C                 CALCULATE TOTAL UNCERTAINTY FOR COST
  C    (COMMITMENTS LAG TIME SO IF ACTC=0 IT DOES NOT NECESSARILY IMPLY
  C     THAT THE PROJECT IS BEHIND SCHEDULE)
         IF (ACTC(P1) .EQ.  0.0) GO TO 122
         DO 110 J=P2,100,K2
         XJ=J
          D1C=.95
          D2C=.001
          D1T=.97
          D2T=.001
         UT(J)=D1T-(XJ-P2)*D2T
         UC(J)=D1C-(XJ-P2)*D2C
  110    CONTINUE
         GO TO 123
  122    DO 120 J=P2,100,K2
         UC(J)=1.0
         UT(J)=0.95-(J-P2)*0.0015
  120    CONTINUE
  C
  C           DETERMINE P3, P4, P5, P6
  123    P3=0.0
         DO 150 J=1,P1-1,1
         IF (ACTT(J) .GT.  0.0) P3=J
  150    CONTINUE
         DO 160 J=K2,100,K2
         IF(P3 .LT.  J)GO TO 170
  160    CONTINUE
  170    P4=J
         P5=J-K2
         P6=P2-K2
  C                       CALCULATE THE COMPARISON SLOPES
         GRADAC=(ACTC(P1))/(P1-P3)
```

```
$S  LIST OF FILE              GRAM

      GRADAT=(ACTT(P1))/(P1-P3)
C
      TOTGC=0.0
      TOTGT=0.0
      IF(P3 .EQ.  0.0) GO TO 155
      DO 180  J=P4+K2,P6,K2
      TOTGC=TOTGC+COST(K1-1,J)
      TOTGT=TOTGT+TIME(K1-1,J)
180   CONTINUE
      IF (P2 .GT.  P4)GO TO 190
      TOTGC=(COST(K1-1,P4)/(P4-P3))*(P1-P3)
      TOTGT=(TIME(K1-1,P4)/(P4-P3))*(P1-P3)
      GO TO 200
155   DO 165  J=K2,P6,K2
      TOTGC=TOTGC+COST(K1-1,J)
      TOTGT=TOTGT+TIME(K1-1,J)
165   CONTINUE
      TOTGC=TOTGC+(COST(K1-1,P2)/K2)*(P1-P6)
      TOTGT=TOTGT+(TIME(K1-1,P2)/K2)*(P1-P6)
      GO TO 200
190   TOTGC=TOTGC+COST(K1-1,P4)+(COST(K1-1,P2)/K2)*(P1-P6)
      TOTGT=TOTGT+TIME(K1-1,P4)+(TIME(K1-1,P2)/K2)*(P1-P6)
200   GRADC1=TOTGC/(P1-P3)
      GRADT1=TOTGT/(P1-P3)
      CGRAD1=(GRADAC/GRADC1)
      CGRAD2=(GRADAT/GRADT1)
      ENC=CGRAD1-CGRADC(K1-1)
      ENT=CGRAD2-CGRADT(K1-1)
      ENTA=ABS(ENT)
      ENCA=ABS(ENC)
      ENT=EOT+G*(ENT-EOT)
      ENC=EOC+G*(ENC-EOC)
      ENCA=EOCA+G*(ENCA-EOCA)
      ENTA=EOTA+G*(ENTA-EOTA)
      ST=ABS(ENT/ENTA)
      SC=ABS(ENC/ENCA)
      EOT=ENT
      EOC=ENC
      EOCA=ENCA
      EOTA=ENTA
      CGRADC(K1)=CGRADC(K1-1)+SC*(CGRAD1-CGRADC(K1-1))
      CGRADT(K1)=CGRADT(K1-1)+ST*(CGRAD2-CGRADT(K1-1))
C               CALCULATE THE FORECASTED GRADIENTS
      IF((P2-P3) .LT.  K2) GO TO 205
      GRADC(P1)=(COST(K1-1,P2)*UC(P2)+COST(K1-1,P2)*(1-UC(P2))*CGRADC(K1
     &))/K2
      GRADT(P1)=(TIME(K1-1,P2)*UT(P2)+TIME(K1-1,P2)*(1-UT(P2))*(CGRADT
     &(K1)))/K2
      GO TO 207
205   GRADC(P1)=(COST(K1-1,P2)*UC(P2)+COST(K1-1,P2)*(1-UC(P2))*CGRADC(K1
     &))/(P2-P3)
      GRADT(P1)=(TIME(K1-1,P2)*UT(P2)+TIME(K1-1,P2)*(1-UT(P2))*(CGRADT
     &(K1)))/(P2-P3)
207   DO 210 J=P2+K2,100,K2
      GRADC(J-K2)=(COST(K1-1,J)*UC(J)+COST(K1-1,J)*(1-UC(J))*CGRADC(K1))
     &/K2
      GRADT(J-K2)=(TIME(K1-1,J)*UT(J)+TIME(K1-1,J)*(1-UT(J))*(CGRADT(K
     &1)))/K2
210   CONTINUE
C               CALCULATE THE FORECASTED POINTS
      COST(K1,P2)=GRADC(P1)*(P2-P1)
      TIME(K1,P2)=GRADT(P1)*(P2-P1)
```

```
 LIST OF FILE              GRAM

      DO 220 J=P2+K2,100,K2
      COST(K1,J)=GRADC(J-K2)*K2
      TIME(K1,J)=GRADT(J-K2)*K2
220   CONTINUE
C*************************************************************************
C                     REPORT WRITING ROUTINES
C                          REPORT NO.  1
C*************************************************************************
      WRITE(8,289)
289   FORMAT('1')
      WRITE(8,300)
300   FORMAT(45X,'GENERALISED RESOURCE APPRAISEMENT MODEL',/57X,'MONTHLY
     & REPORT',/ 57X,14('*'))
      K6=K1-1
      WRITE(8,302)K6,ST,SC
302   FORMAT(/2X,'REPORT NUMBER',I3,/2X,'SMOOTHING CONSTANTS: TIME-',F
     &5.3,/23X,'COST-',F5.3)
      WRITE(8,304)
304   FORMAT(/12X,52('*'),1X,67('*'),
     &/12X,'*',20X,'TIME (DAYS)',19X,'*',1X,'*',25X,'COMMITMENTS (R000'S
     &)',20X,'*',
     &/ 4X,7('*'),' *',1X,48('-'),1X,'*',1X,'*',1X,63('-'),1X,'*',
     &/ 4X,'*  %  * * U/T *  BUDGET  *   ACTUAL *',
     &' FORECAST *PROGRESSIVE* *',
     &' U/C *    BUDGET    *     ACTUAL    *',
     &'    FORECAST  *  PROGRESSIVE *',
     &/ 4X,'* COMP* *     *',3(' PROG  CUM*'),' VAR  %VAR ',
     &'* *     *',3(' PROG    CUM  *'),'   VAR    %VAR*',/4X,128('*'))
C          ZERO APPROPRIATE VARIABLES
      A10=0.0
      A11=0.0
      A12=0.0
      A13=0.0
      TOTT2=0.0
      TOTC2=0.0
      TOTBAC=0.0
      TOTBAT=0.0
C          IDENTIFY THOSE ORDINATES OF % COMPLETION WHICH HAVE BEEN USED
C          IN UPDATES
      DO 306 JACT=1,P1,1
      IF (ACTT(JACT) .GT.  0.0) GO TO 308
306   CONTINUE
      IF((P2-P1) .LT.  K2) GO TO 328
      GO TO 316
308   A1=JACT
C       IDENTIFY THE INTERVAL THAT JACT FALLS IN
      DO 310 J=K2,100,K2
      IF (JACT .LE.  J)GO TO 312
310   CONTINUE
312   INTT=(PT(K5,J)/K2)*(JACT-J+K2)
      INTC=(PC(K5,J)/K2)*(JACT-J+K2)
      TT1=0.0
      TC1=0.0
      TT2=0.0
      TC2=0.0
      TOTBC=0.0
      TOTBT=0.0
      TT3=0.0
      TC3=0.0
      TT4=0.0
      TC4=0.0
      IF(J .LE.  K3)GO TO 323
```

```
$ LIST OF FILE              GRAM

      &000.,A13/1000.,A8/1000.,A9
       P2=P2+K2
       GO TO 316
 314   FORMAT( 4X,'*',F5.1,'* *',5X,'*',2(F4.0,1X,F5.0,'*'),10X,'*',F4.0,
      &1X,F6.2,'* *',5X,'*',2(F6.0,1X,F7.0,'*'),14X,'*',F7.0,1X,F6.2,'*')
 C            PRINT FORECASTED PARAMETERS
 316   DO 320 J=P2,100,K2
       A1=J
       A2=PT(K5,J)
       A3=TIME(K1,J)
       A4=PC(K5,J)
       A5=COST(K1,J)
       A6=A3-A2
       A7=(A3/A2 -1.)*100.
       A8=A5-A4
       A9=(A5/A4-1.)*100.
       TOTT2=TOTT2+A3
       TOTC2=TOTC2+A5
       A10=A10+A2
       A11=A11+A3
       A12=A12+A4
       A13=A13+A5
       A14=UT(J)
       A15=UC(J)
       TT3=A10-TT2
       TC3=A12-TC2
       TT4=A11-TT1
       TC4=A13-TC1
       WRITE(8,318)A1,A14,A2,A10,A3,A11,A6,A7,A15,A4/1000.,A12/1000.,A5/1
      &000.,A13/1000.,A8/1000.,A9
 318   FORMAT( 4X,'*',F5.1,'* *',F4.3,' *',F4.0,1X,F5.0,'*',10X,'*',F4.0,
      &1X,F5.0,'*',F4.0,1X,F6.2,'* *',F4.3,' *',F6.0,1X,F7.0,'*',14X,'*',
      &F6.0,1X,F7.0,'*',F7.0,1X,F6.2,'*')
 320   CONTINUE
       WRITE(8,330)
 330   FORMAT(4X,128('*'))
 C            PRINT COLUMN TOTALS
       TC5=TC2+TC3
       TC6=TC1+TC4
       TT5=TT2+TT3
       TT6=TT1+TT4
       WRITE(8,720)
 720   FORMAT( /4X,'SUMMARY',44X,'TO DATE',18X,'TO COMPLETION',17X,'TOTAL
      & PROJECT',/4X,7('-'),31X,3(1X,28('-'),1X))
       WRITE(8,730)
 730   FORMAT(42X,3(6X,'DAYS',6X,'RANDS (000'S)',1X)
      &/42X,3(2(1X,13('-'),1X)))
       WRITE(8,740)TT2,TC2/1000.,TT3,TC3/1000.,TT5,TC5/1000.
 740   FORMAT(4X,'BUDGET',32X,3(5X,F6.1,8X,F7.0,4X))
       WRITE(8,750)TT1,TC1/1000.,TT4,TC4/1000.,TT6,TC6/1000.
 750   FORMAT(4X,'ACTUAL/FORECASTED',21X,3(5X,F6.1,8X,F7.0,4X))
       WRITE(8,760)TT1-TT2,(TC1-TC2)/1000.,TT4-TT3,(TC4-TC3)/1000.,TT6-TT
      &5,(TC6-TC5)/1000.
 760   FORMAT(4X,'VARIANCE',30X,3(5X,F6.1,8X,F7.0,4X))
       WRITE(8,770)(TT1/TT2-1.)*100.,   (TC1/TC2-1.)*100.,(TT4/TT3-1.)*100
      &.,(TC4/TC3-1.)*100.,(TT6/TT5-1.)*100.,(TC6/TC5-1.)*100.
 770   FORMAT(4X,'% VARIANCE',28X,3(5X,F6.1,8X,F7.0,4X))
       WRITE(8,780)
 780    FORMAT(/4X,128('*'))
 5000  CONTINUE
 C
 C*************************************************************************
```

```
$  LIST OF FILE              GRAM

C             DETERMINE TOTAL BUDGETS TO DATE
      DO 322 J1=K2,J-K2,K2
      TOTBT=TOTBT+PT(K5,J1)
      TOTBC=TOTBC+PC(K5,J1)
322   CONTINUE
332   TOTBT=TOTBT+INTT
      TOTBC=TOTBC+INTC
C       DETERMINE PRINTOUT VALUES AND TOTAL BUDGET ALREADY EXPENDED
      A2=TOTBT-TOTBAT
      A10=A10+A2
      A3=ACTT(JACT)
      A6=A3-A2
      A7=(A3/A2 -1. )*100.
      A4=TOTBC-TOTBAC
      A5=ACTC(JACT)
      A8=A5-A4
      A9=(A5/A4-1. )*100.
      A11=A11+A3
      A12=A12+A4
      A13=A13+A5
      TT1=A11
      TC1=A13
      TT2=A10
      TC2=A12
      TOTBAT=TOTBAT+A2
      TOTBAC=TOTBAC+A4
      TOTT2=TOTT2+A3
      TOTC2=TOTC2+A5
      WRITE(8,314)A1,A2,A10,A3,A11,A6,A7,A4/1000.,A12/1000.,A5/1000.,A13
     &/1000.,A8/1000.,A9
      GO TO 306
C             IF P1 IS NOT AN ORDERED ORDINATE,THE VALUES OF P2 ARE
C             PRINTED HERE.
328   IP2=P2
      A1=P2
      TOTBC=0.0
      TOTBT=0.0
      DO 334  J=K2,IP2,K2
      TOTBT=TOTBT+PT(K5,J)
      TOTBC=TOTBC+PC(K5,J)
334   CONTINUE
      A2=TOTBT-TOTBAT
      A4=TOTBC-TOTBAC
      A3=TIME(K1,IP2)
      A5=COST(K1,IP2)
      A6=A3-A2
      A7=(A3/A2 -1. )*100.
      A8=A5-A4
      A9=(A5/A4-1. )*100.
      TOTT2=TOTT2+A3
      TOTC2=TOTC2+A5
      A10=A10+A2
      A11=A11+A3
      A12=A12+A4
      A13=A13+A5
      A14=UT(P2)
      A15=UC(P2)
      TT3=A10-TT2
      TC3=A12-TC2
      TT4=A11-TT1
      TC4=A13-TC1
```

```
 LIST OF FILE              GRAM

C                    DATA OUTPUT AND PROGRAM EXIT ROUTINES
C*************************************************************************
700    DUMMY=1
       END
```

G-2 SAMPLE OUTPUT REPORT

EXPLANATORY COMMENTS

Report Number = the update number during which the report was produced.

Smoothing Constants = the smoothing constant which was caluclated using the simple Trigg and Leach approach.

DlT = the constant D1t which was used during the run.

D2T = the constant D2t which was used during the run.

D1C = the equivalent to Ol_t for cost.

D2C = the equivalent to D2t for cost.

= the smoothing factor g used to calculate the smoothing constants.

% Comp = the percentage completion.

U/T = the certainty factor for time calculated for the ordered values of % completion.

Budget = the originally voted budget for cost and the originally scheduled plan for time.

Actual = the reported parameters.

Forecast = the forecasted parameters.

Prog = the progressive parameters, e.g. it was budgeted that 49 days would be required to progress the PPC from 60% to 65%.

Cum = the cumulative total, e.g. it was budgeted that the project would be 80% complete after R129 645 000 had been spent.

Progressive Var = the difference between what was budgeted and what was forecasted or reported for an interval of PPC.

Progressive % Var	= the percentage progressive variance.
To Date	= the state of affairs at the present update,s value of PPC.
To Completion	= the state of affairs forecasted from the present update,s value of PPC to when the project will be 100% complete.
Total Project	= the forecasted state of affairs for the total project.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 4 SMOOTHING CONSTANTS: TIME= .609 COST= .505 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

TIME (DAYS)										COMMITMENTS (R000'S)									
% COMP		U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR		U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0			64.	64.	43.	43.			-21.	-33.39			12400.	12400.	7970.	7970.			-4430.	-35.73
4.0			64.	128.	41.	83.			-23.	-36.25			12400.	24800.	7629.	15599.			-4771.	-38.48
6.0			48.	176.	40.	123.			-8.	-17.56			9800.	34600.	7399.	22998.			-2400.	-24.49
8.0			34.	210.	33.	156.			-1.	-1.65			7200.	41800.	6253.	29251.			-947.	-13.15
10.0		.970	34.	244.			32.	189.	-2.	-5.14		.950	7200.	49000.			6690.	35942.	-510.	-7.08
15.0		.962	68.	312.			65.	253.	-3.	-4.96		.940	11000.	60000.			10085.	46027.	-915.	-8.32
20.0		.953	80.	392.			75.	329.	-5.	-5.91		.930	9500.	69500.			8594.	54621.	-906.	-9.54
25.0		.944	28.	420.			26.	355.	-2.	-6.85		.920	3500.	73000.			3124.	57745.	-376.	-10.75
30.0		.936	43.	463.			40.	394.	-3.	-7.79		.910	6000.	79000.			5283.	63028.	-717.	-11.94
35.0		.928	36.	499.			33.	427.	-3.	-8.71		.900	4000.	83000.			3475.	66503.	-525.	-13.13
40.0		.919	32.	531.			29.	456.	-3.	-9.63		.890	5000.	88000.			4285.	70788.	-715.	-14.30
45.0		.911	31.	562.			28.	484.	-3.	-10.55		.880	5000.	93000.			4227.	75015.	-773.	-15.46
50.0		.902	29.	591.			26.	510.	-3.	-11.45		.870	5000.	98000.			4169.	79184.	-831.	-16.61
55.0		.894	32.	623.			28.	538.	-4.	-12.35		.860	5000.	103000.			4112.	83297.	-888.	-17.75
60.0		.885	23.	646.			20.	558.	-3.	-13.25		.850	4750.	107750.			3853.	87150.	-897.	-18.88
65.0		.877	49.	695.			42.	600.	-7.	-14.14		.840	8250.	116000.			6600.	93750.	-1650.	-19.99
70.0		.868	46.	741.			39.	639.	-7.	-15.02		.830	10750.	126750.			8482.	102232.	-2268.	-21.10
75.0		.860	50.	791.			42.	681.	-8.	-15.89		.820	6250.	133000.			4863.	107095.	-1387.	-22.19
80.0		.851	78.	869.			65.	746.	-13.	-16.76		.810	9750.	142750.			7481.	114576.	-2269.	-23.27
85.0		.843	87.	956.			72.	817.	-15.	-17.62		.800	10250.	153000.			7755.	122331.	-2495.	-24.34
90.0		.834	109.	1065.			89.	906.	-20.	-18.47		.790	9500.	162500.			7087.	129418.	-2413.	-25.40
95.0		.826	140.	1205.			113.	1019.	-27.	-19.32		.780	10000.	172500.			7355.	136773.	-2645.	-26.45
100.0		.817	195.	1400.			156.	1175.	-39.	-20.17		.770	10500.	183000.			7614.	144387.	-2886.	-27.49

SUMMARY

	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	210.0	41800.	1190.0	141200.	1400.0	183000.
ACTUAL/FORECASTED	156.4	29251.	1018.4	115135.	1174.8	144387.
VARIANCE	-53.6	-12549.	-171.6	-26065.	-225.2	-38613.
% VARIANCE	-25.5	-30.	-1.4	-18.	-16.1	-21.

APPENDIX H

DATA OBTAINED FROM RECORDS OF BEISA MINES LIMITED

TABLE M-1 : RAW DATA : TIME VS PPC

CONSTRUCTION COMMENCED ON 1ST JULY 1978

Report No.	Cut-off Date	Days		PPC	
		Progressive	Cumulative	Scheduled	Actual
	31/07/78	31	31	0,5	1,4
	31/08/78	31	62	1,8	3,0
	30/09/78	30	92	2,4	4,4
	31/10/78	31	123	3,8	6,0
	30/11/78	30	153	4,6	7,8
	31/12/78	31	184	6,2	9,6
1	31/01/79	31	215	8,0	12,0
2	28/02/79	28	243	10,0	14,2
3	29/03/79	29	272	12,2	17,1
4	30/04/79	32	304	14,4	19,4
5	31/05/79	31	334	17,0	21,8
6	30/06/79	30	364	19,5	25,0
7	31/07/79	31	395	22,8	27,5
8	31/08/79	31	426	25,6	29,5
9	30/09/79	30	456	29,2	32,0
10	31/10/79	31	487	33,0	35,3
11	30/11/79	30	517	38,2	38,5
12	31/12/79	31	548	42,4	39,7
13	31/01/80	31	579	48,0	42,6
14	29/02/80	29	608	52,8	45,7
15	31/03/80	31	639	57,4	48,7
16	30/04/80	30	669	61,4	53,1
17	31/05/80	31	700	65,6	57,8
18	30/06/80	30	730	68,8	61,2
19	31/07/80	31	761	72,2	64,4

TABLE N-1 (continued)

Report No.	Cut-off Date	Days		PPC	
		Progressive	Cumulative	Scheduled	Actual
20	31/08/80	31	792	75,0	68,7
21	30/09/80	30	822	77,0	71,3
22	31/10/80	31	853	79,0	73,8
23	30/11/80	30	883	80,8	77,1
24	31/12/80	31	914	83,0	78,1
25	31/01/81	31	945	84,4	80,7
26	28/02/81	28	973	85,8	83,3
27	31/03/81	31	1 004	87,0	85,3
28	30/04/81	30	1 034	88,4	87,0
29	31/05/81	31	1 065	90,0	89,0
30	30/06/81	30	1 095	91,2	91,0
31	31/07/81	31	1 126	92,2	93,0
32	31/08/81	31	1 157	93,4	94,2
33	31/09/81	30	1 187	94,4	94,8
34	31/10/81	31	1 218	95,4	95,2
35	30/11/81	30	1 248	96,4	95,6
36	30/12/81	30	1 278	97,2	96,0
			1 400	100,0	

NOTE: This data was obtained from the original project schedule and the monthly progress reports of the project.

TABLE 8-2 : RAW DATA : COMMITMENTS VS PPC

CONSTRUCTION COMMENCED 1ST JULY 1978

COMMITMENTS 000,S OF RANDS

Budget •	Days	Actual	
Commitments	Cumulative	Actual PPC	Cumulative
	31	1,4	5796.3
	62	3,0	11592.6
	92	4,4	17201.8
	123	6,0	22998.1
27 500	153	7,8	28607.4
	184	9,6	34403.7
42 500	215	12,0	40200
49 000	243	14,2	46639
51 000	272	17,1	48598
57 500	304	19,4	52456
	334	21,8	52786
65 000	364	25,0	53982
67 500	395	27,5	55062
	426	29,5	58528
76 000	456	32,0	60430
	487	35,3	62200
83 000	517	38,5	64488
	548	39,7	70639
93 500	579	42,6	72361
99 000	608	45,7	73725
105 000	639	48,7	75215
	669	53,1	78377
117 000	700	57,8	83264
122 500	730	61,2	85166
127 500	761	64,4	27021
133 000	792	68,7	89920
	822	71,3	92726

TABLE H2 (continued)

COMMITMENTS (000,S OF RANDS)

Budget *	Days	Actual	
Commitments	Cumulative	Actual PPC	Cumulative
	853	73,8	96729
145 000	883	77,1	99732
	914	78,1	101723
152 500	945	20,7	104913
155 000	973	83,3	107558
	1 004	85,3	110785
	1 034	87,0	113490
162 500	1 065	89,0	115744
	1 095	91,0	118389
167 500	1 126	93,0	120664
	1 157	94,2	123718
	1 187	94,8	128364
	1 218	95,2	132125
175 000	1 248	95,6	134938
	1 278	96,0	138011
183 000	1 400		

* The budget figures were obtained from a commitments vs time S-curve depicting the budgeted expenditure. It is the only available source of the information required.

The actual figures were obtained from the monthly progress reports.

TABLE M3 : TIME VS PCC (Budget and Actual)

CONSTRUCTION COMMENCED 1ST JULY 1978

PPC	Time (Days)			
	Budget		Actual	
	Progressive	Cumulative	Progressive	Cumulative
2			43,63	42,63
4			41,80	83,43
5	160	160		
6			39,57	123,00
8			33,44	156,44
10	84	244	32,73	189,17
12			25,83	215,00
14			25,45	240,95
15	68	312		
16			20,55	261,00
18			23,52	284,52
20	80	392	26,98	311,50
22			24,38	335,88
24			18,75	354,63
25	28	420		
26			21,77	376,40
28			26,35	402,75
30	43	463	29,25	432,00
32			24,00	456,00
34			18,79	474,79
35	36	499		
36			18,77	493,56
38			18,75	512,31
40	32	531	38,90	551,21
42			21,38	572,59
44			19,51	592,10
45	31	562		
46			19,00	611,10
48			20,67	631,77

TABLE H3 (continued)

PPC	Time (Days)			
	Budget		Actual	
	Progressive	Cumulative	Progressive	Cumulative
50	29	591	16,09	647,86
52			13,64	661,50
54			13,44	674,94
55	32	623		
56			13,19	688,13
58			13,63	701,76
60	23	646	18,30	720,06
62			17,69	737,75
64			19,38	757,13
65	49	695		
66			15,40	772,53
68			14,42	786,95
70	46	741	19,49	806,44
72			23,31	829,75
74			25,07	854,82
75	50	791		
76			18,18	873,00
78			37,90	910,90
80	78	869	25,75	936,65
82			22,35	959,00
84			24,85	983,85
85	87	956		
86			32,50	1016,35
88			33,15	1049,50
90	109	1065	30,50	1080,00
92			30,50	1110,50
94			41,33	1151,83
95	140	1205	50,67	1202,50
96			75,50	1278,00
100	195	1400		

This data was obtained by interpolating the data in Table H-1.

TABLE H4 : COMMITMENTS VS PPC (Budget and Actual)

CONSTRUCTION COMMENCED ON 1ST JULY 1978

	Commitments (R000,s)			
PPC	Budget		Actual	
	Progressive	Cumulative	Progressive	Cumulative
2			7969,91	7969,91
4			7628,69	15598,60
5	31 000	31 000		
6			7399,50	22998,1
8			6253,33	29251,43
10	18 000	49 000	6118,37	35369,80
12			4830,20	40200,00
14			5853,64	46053,64
15	11 000	60 000		
16			1801,29	47854,93
18			2252,72	50107,65
20	9 500	69 500	2430,85	52538,50
22			322,25	52860,25
24			747,50	53608,25
25	3 500	73 000		
26			805,75	54414,00
28			1514,50	55928,50
30	6 000	79 000	2979,90	58908,40
32			1521,60	60430,00
34			1072,73	61502,73
35	4 000	83 000		
36			1197,79	62700,50
38			1430,00	64130,50
40	5 000	88 000	6686,64	70817,14
42			1187,58	72004,72
44			972,28	72977,00
45	5 000	93 000		
46			897,00	73874,00
48			993,33	74867,33
50	5 000	98 000	1282,23	76149,23

TABLE M4 (continued)

PPC	Commitments (8000•s)			
	Budget		Actual	
	Progressive	Cumulative	Progressive	Cumulative
52			1437,27	77586,50
54			1726,31	79312,81
55	5 000	103 000		
56			2079,57	81392,38
58			1983,50	83325,88
60	4 750	107 750	118,83	84494,71
62			1135,04	85629,75
64			1159,38	86789,13
65	8 250	116 000		
66			1310,57	88099,70
68			1348,37	89448,07
70	10 750	126 750	1822,97	91271,04
72			2455,71	93726,75
74			3184,25	96911,00
75	6 250	133 000		
76			1820,00	98731,00
78			2792,90	101523,90
80	9 750	142 750	2530,25	104 054,15
82			2181,35	106 235,50
84			2452,45	108 687,45
85	10 250	153 000		
86			3211,37	111898,82
88			2718,18	114617,00
90	9 500	162 500	2449,50	117066,50
92			2460,00	119526,5
94			3682,50	123209,00
95	10 000	172 500	7035,50	130244,50
96			7766,50	138011,00
100	10 500	183 000		

This data was obtained by interpolating the data in Table H-2.

TABLE M-5 : SUBJECTIVE FORECASTS OF TOTAL PROJECT COST (Raw Data)

Report Number	Days (Cumulative)	Forecast R(000,s)	Actual PPC
1	215	180 573	12,0
2	243	180 264	14,2
3	272	179 777	17,1
4	304	180 527	19,4
5	334	179 466	21,8
6	364	179 709	25,0
7	395	173 087	27,5
8	426	173 447	29,5
9	456	173 727	32,0
10	487	173 729	35,3
11	517	173 404	38,5
12	548	174 236	39,7
13	579	174 165	42,6
14	608	174 253	45,7
15	639	174 313	48,7
16	669	174 083	53,1
17	700	174 372	57,8
18	730	161 757	61,2
19	761	161 184	64,4
20	792	Not available	68,7
21	822	145 915	71,3
22	853	145 728	73,8
23	883	143 906	77,1
24	914	142 709	78,1
25	945	144 199	80,7
26	973	144 772	83,3
27	1 004	146 811	85,3
28	1 034	147 040	87,0
29	1 065	146 924	89,0
30	1 095	147 199	91,0
31	1 126	147 199	93,0

TABLE M-5 (continued)

Report Number	Days (Cumulative)	Forecast R(000,s)	Actual PPC
32	1 157	147 199	94,2
33	1 187	146 082	94,8
34	1 218	140 790	95,2
35	1 248	140 790	95,6
36	1 278	138 611	96,0

This data was obtained from monthly progress reports.

TABLE H-6 : SUBJECTIVE FORECASTS (ADJUSTED FOR REGULAR INTERVALS OF PPC)

PPC	Forecast R000,s
2	183 000
4	183 000
6	183 000
8	183 000
10	183 000
12	180 573
14	180 573
16	180 264
18	179 777
20	180 527
22	179 466
24	179 466
26	179 709
28	173 087
30	173 447
32	173 727
34	173 727
36	173 729
38	173 404
40	174 236
42	174 236
44	174 165
46	174 253
48	174 253
50	174 313
52	174 313
54	174 083

PPC	Forecast R000,s
58	174 372
60	174 372
62	161 757
64	161 184
66	161 184
68	161 184
70	161 184
72	145 915
74	145 728
76	143 906
78	,143 906
80	142 709
82	144 199
84	144 772
86	146 811
88	147 040
90	146 924
92	147 199
94	147 199
95	146 082
96	138 611

Mean forecast = R166 340 000

Standard deviation = R 14 735 000

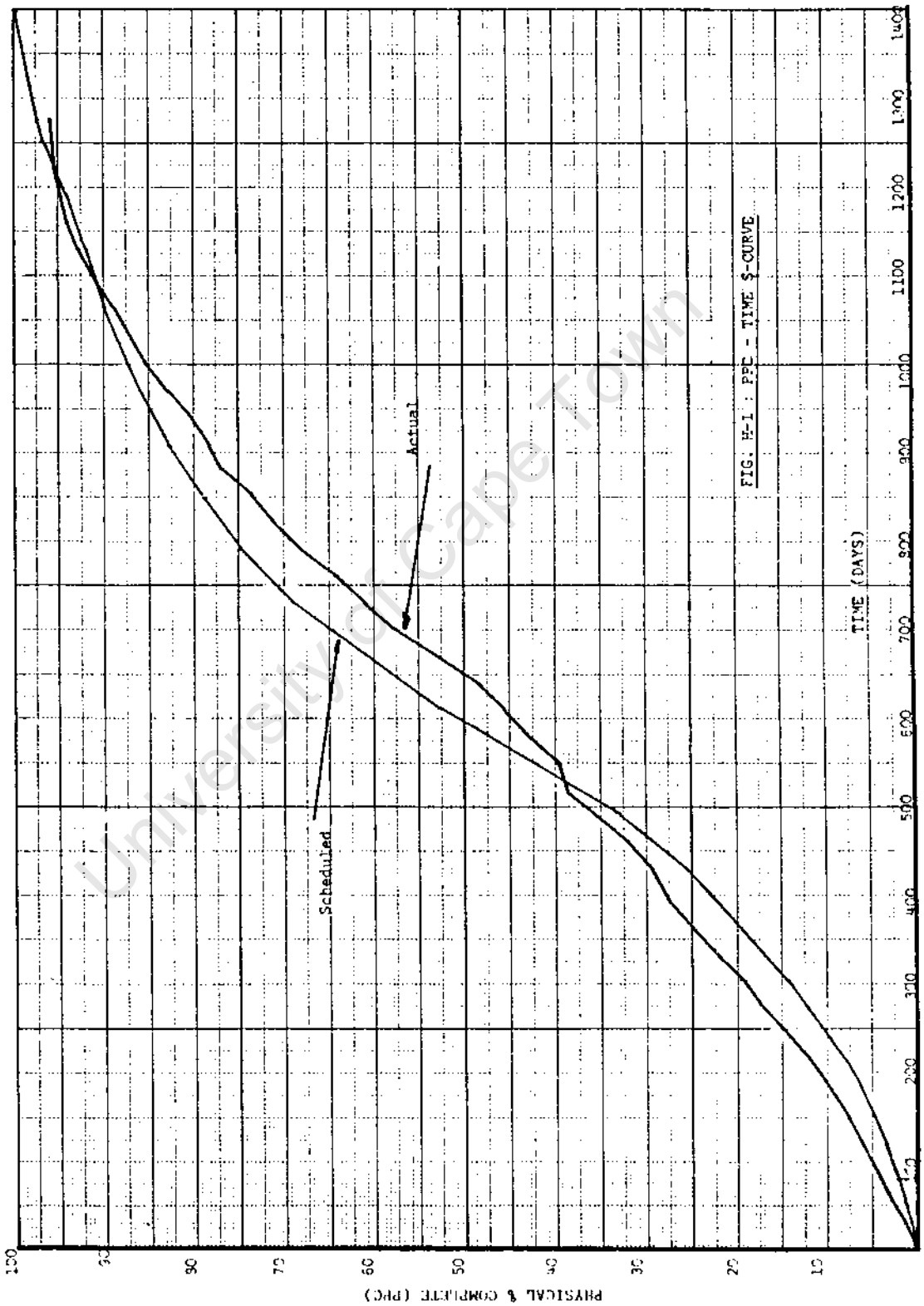
Table M-6 was obtained from Table H-5 as follows:
The subjective forecasts are calculated on a monthly basis by considering the discrepancies in outstanding contracts. Hence what this forecast actually is made up of is

FORECAST BUDGET + VARIANCE OF WORK IN-PROGRESS

These forecasts assume that the budget will be adhered to in the future.

It is therefore not meaningful to interpolate the data in Table H-5 for regular intervals of PPC since the function of forecasts vs PPG is in fact a step function - the forecasts undergo step changes at each new forecast period. Hence it is assumed here that if, for example, we wish to know what the forecast was at 7OPPC, we use the value which was forecasted immediately before 7OPPC, i.e.
R161 184 000.

FIGURE H-1



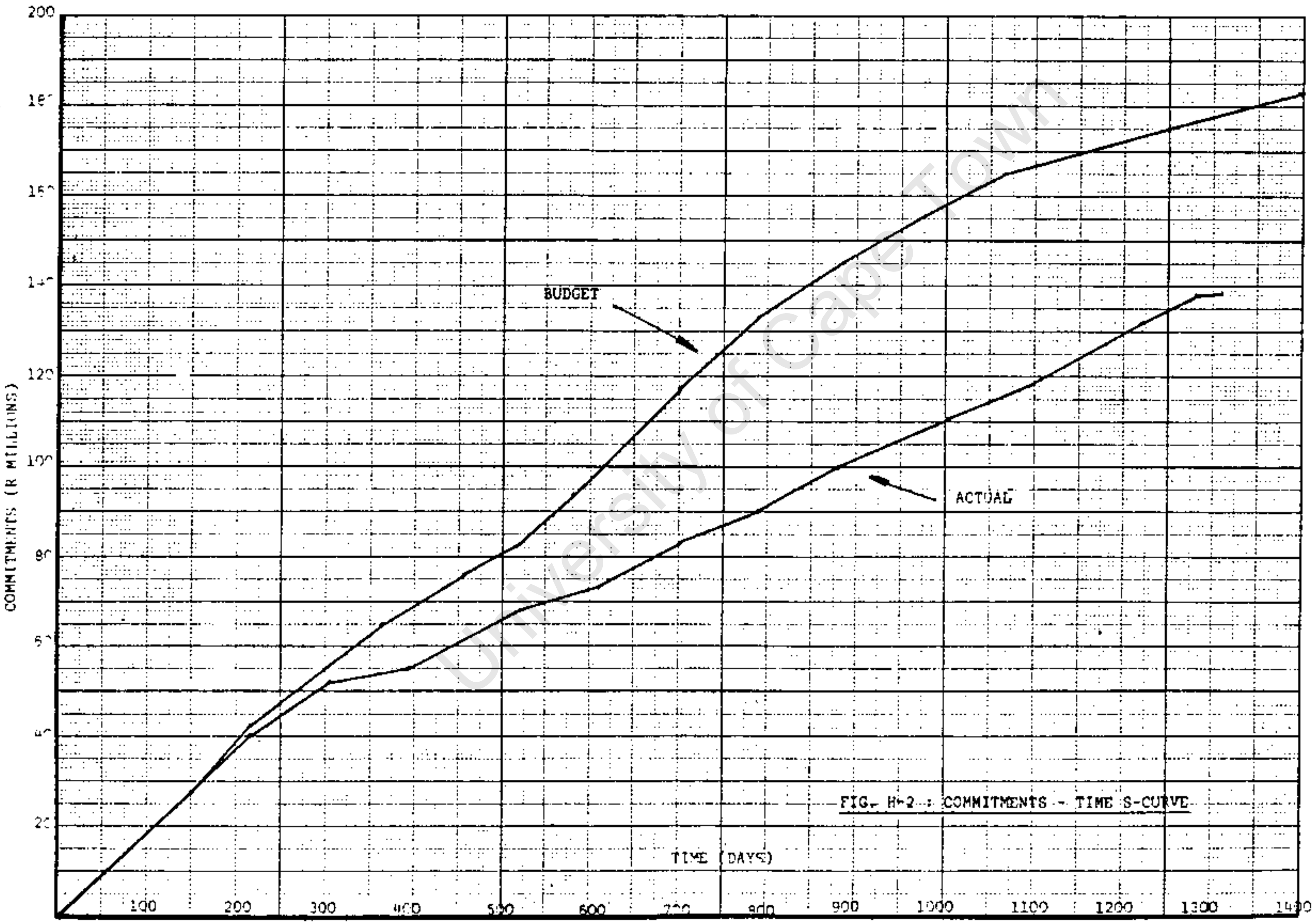


FIGURE H-2

FIGURE H-3

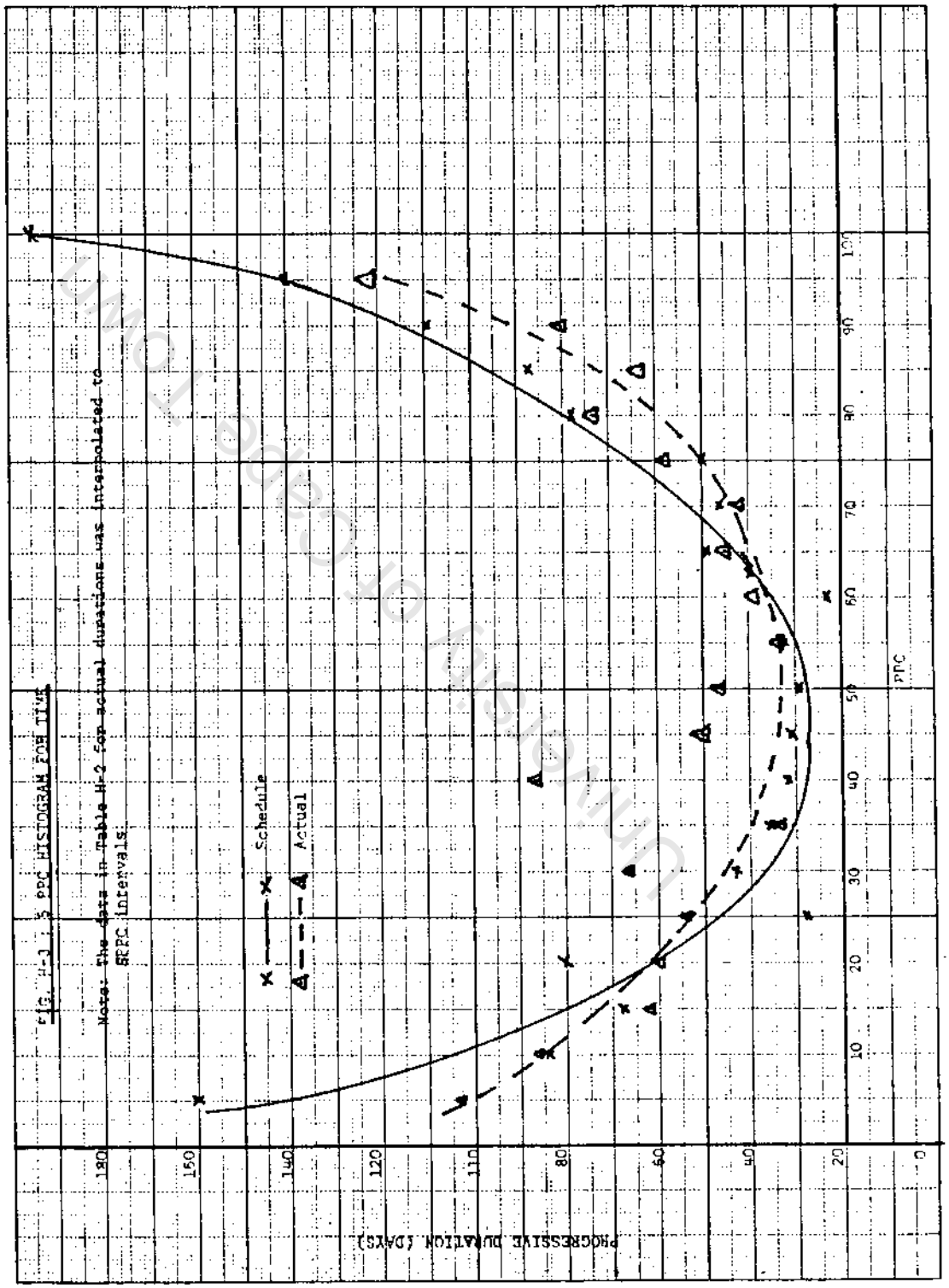


FIG. H-3 S PPC HISTOGRAM FOR TIVE
Note: The data in Table H-2 for actual durations was interpolated to
5PPC intervals.
Schedule
Actual
PROGRESSIVE DURATION (DAYS)
PPC

FIGURE H-4

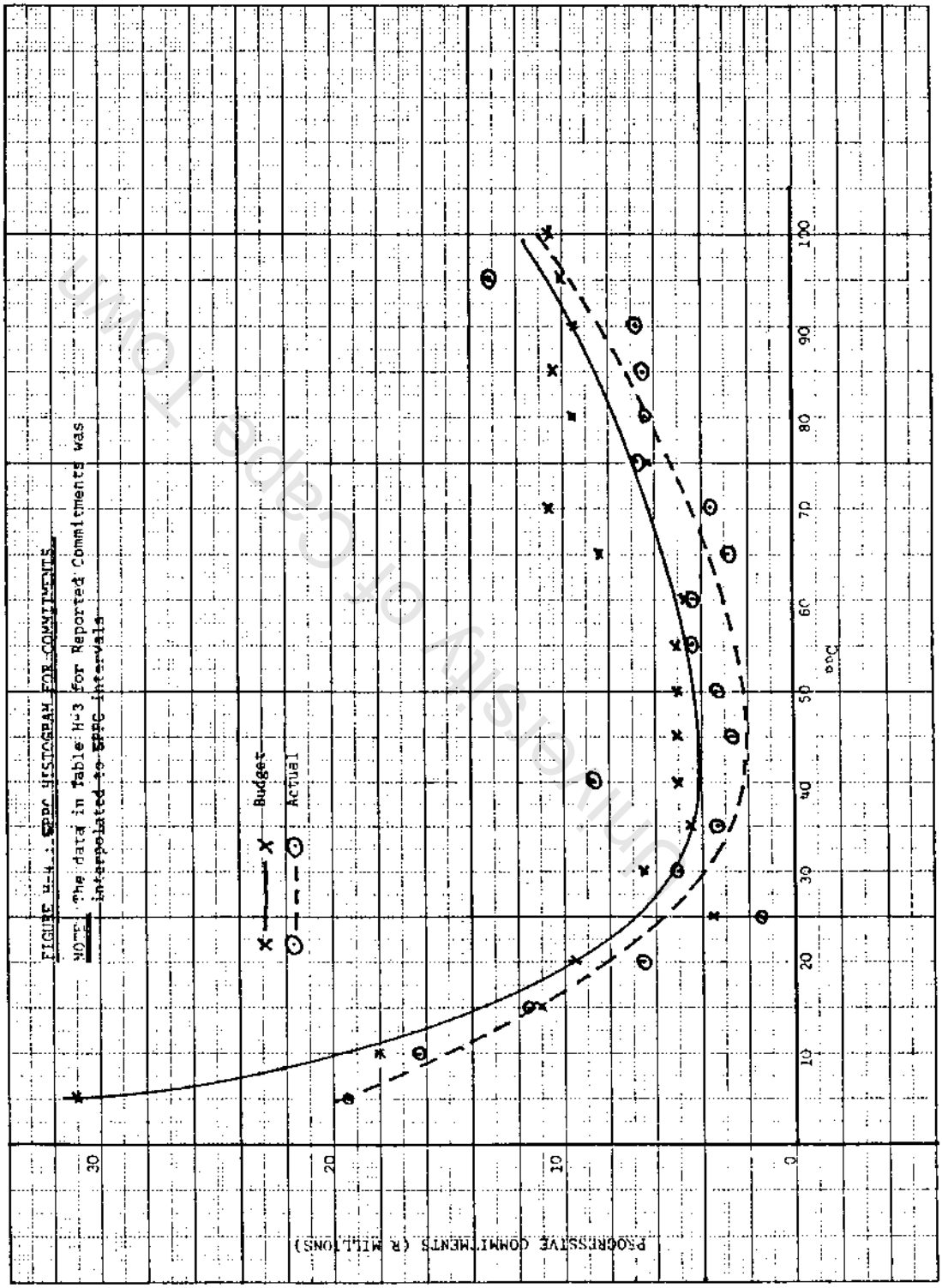


FIGURE H-4 -- EPRC HISTOGRAM FOR COMMITMENTS
NOTE: The data in Table H-3 for Reported Commitments was interpolated to EPRC intervals
Budget
Actual
PROGRESSIVE COMMITMENTS (R MILLIONS)
0
10
20
30
40
50
60
70
80
90
100
Days

APPENDIX I

RESULTS OF SENSITIVITY ANALYSIS

TABLE I-lA : g = 0,3 D_I = 0,99

PPC	Time (Days)		Commitments (R000,s)	
	D2 = 0,001	D2 = 0,0001	D2 = 0,001	D2 = 0,0001
2	1349,4	1371,7	175 216	177 686
6	1260,1	1325,9	161 858	168 961
10	1246,2	1322,0	156 841	166 219
16	1225,0	1307,7	159 738	166 760
20	1195,2	1290,0	154 430	163 178
26	1371,5	1355,8	142 939	157 759
30	1482,2	1397,7	140 547	156 792
36	1592,2	1436,4	139 656	155 581
40	1720,8	1490,8	150 259	161 953
46	1922,9	1552,4	156 435	161 704
50	1986,9	1576,9	153 259	159 283
56	1969,7	1577,1	151 615	157 977
60	1984,7	1593,2	150 837	157 086
66	1950,9	1584,1	142 868	149 523
70	1909,9	1572,3	137 035	143 732
76	1895,1	1560,6	137 105	143 482
80	1810,9	1551,0	136 613	141 491
86	1700,8	1501,0	134 135	137 749
90	1618,9	1462,4	133 062	135 795
96	1512,8	1424,0	138 584	140 027
Average	1634,8	1462,3	147 651	155 136,9
Standard Deviation	287,3	106,7	11 150	11 560
Maximum Forecast	1986	1593	175 216	177 686
Minimum Forecast	1195	1290	133 062	135 795
Range	791	303	42 154	41 891

NOTE: The figures represent the forecast for the total project made at the respective PPC. Mence when the project was 40 PPC it was forecasted that the duration for the total project would be 1490,8 days and the total commitments would be R161 953 000 (for D_2 = 0,0001).

TABLE I-18 : g = 0,3 D1 = 0,90

	Time Days)		Commitments (R000,s)	
PPC	D2 = 0,01	D2 = 0,001	D2 = 0,01	D2 = 0,001
2	1086,3	1309,3	145 033	169 731
6	719,0	1163,7	98 892	148 690
10	747,6	1170,8	93 158	144 100
16	838,3	1177,5	130 483	158 227
20	826,9	1145,0	119 839	150 419
26	2990,9	1622,8	81 991	127 716
30	5235,5	1858,2	83 418	127 197
36	4965,5	1940,6	101 115	134 457
40	4470,5	2068,9	156 391	161 235
46	4117,3	2290,6	323 774	190 518
50	3398,9	2289,2	240 434	175 907
56	2010,4	2065,2	174 191	163 223
60	1698,3	2011,6	153 913	157 643
66	1415,8	1903,8	120 371	140 435
70	1263,2	1781,2	108 907	130 465
76	1204,2	1660,6	116 627	136 404
80	1212,7	1606,8	119 668	136 975
86	1210,8	1491,6	121 712	133 284
90	1225,1	1429,7	123 963	132 092
96	1302,9	1400,7	136 744	140 486
Average	2096,8	166,9	137 530	147 960
Standard Deviation	1509,9	376,9	56 522,8	17 560,8
Maximum Forecast	5235	2290	323 774	190 518
Minimum Forecast	747,6	1145	81 991	127 197
Range	4488	1145	241 783	63 321

TABLE I-1C : g 0,3 D_i = 0,0

PPC	Time (Days) D2 = 0,0	Commitments (R000,s) D2 = 0,0
2	932,5	117 620
6	977,1	118 572
10	1886,5	204 904
16	1082,9	137 174
20	868,8	93 177
26	999,9	110 987
30	4003,3	167 935
36	994,5	156 795
40	2754,3	304 016
46	9764,0	999 999
50	1955,6	146 319
56	1265,7	137 658
60	2683,2	288 625
66	1806,1	129 314
70	1066,7	98 730
76	2283,8	826 473
80	2029,3	688 074
86	1174,1	121 521
90	1310,5	124 711
96	1475,1	160 928

TABLE 1-2A : g = 0,1 D_I = 0,99

	Time Days)		Commitments (R000,s)	
PPC	D2 = 0,001	D2 = 0,0001	D2 = 0,001	D2 = 0,0001
2	1349,4	1371,7	175 216	177 686
6	1263,2	1325,7	162 114	169 029
10	1238,8	1320,1	156 205	166 043
16	1214,4	1305,1	158 846	166 547
20	1191,8	1289,6	156 239	163 713
26	1337,0	1347,4	146 538	158 843
30	1429,4	1385,5	143 053	157 532
36	1554,7	1428,3	138 500	155 137
40	1677,9	1481,2	146 826	160 744
46	1865,4	1540,1	154 590	161 167
50	1956,0	1570,5	154 218	159 683
56	1969,6	1577,0	153 737	158 769
60	1991,6	1594,0	153 321	157 995
66	1952,7	1581,8	145 130	150 333
70	1913,9	1570,7	139 099	144 460
76	1862,6	1560,1	138 339	143 514
80	1819,8	1550,7	136 534	141 213
86	1709,1	1501,0	133 870	137 482
90	1626,1	1462,5	132 795	135 573
96	1516,1	1423,0	138 343	139 837
Average	1621,5	1459	148 175	155 265
Standard Deviation	287,0	106,8	10 978	11 579
Maximum Forecast	1991	1594	175 216	177 686
Minimum Forecast	1191	1289	132 795	135 573
Range	800	305	42 421	42 113

TABLE 1-2B : g = 0,1 D_I = 0,90

PPC	Time Days) D2 = 0,01	D2 0,001	Commitments (R000's) D2 = 0,01	D2 0,001
2	1086,3	1309,3	145 033	169 731
6	717,4	1164,6	100 574	149 519
10	697,5	1147,5	90 053	142 414
16	779,6	1157,3	129 200	158 299
20	801,3	1148,8	144 931	159 059
26	2474,6	1513,9	101 064	138 899
30	5474,4	1760,2	91 481	131 742
36	8324,6	2019,6	86 882	125 094
40	7740,9	2111,0	117 283	148 574
46	5817,9	2217,8	366 692	204 622
50	4252,6	2244,2	442 977	207 056
56	2310,2	2043,3	303 726	191 480
60	1844,1	2036,2	233 513	181 703
66	1378,3	1877,5	151 050	155 001
70	1216,5	1765,1	124 648	140 763
76	1116,9	1648,5	117 197	135 750
80	1123,9	1583,5	115 300	132 649
86	1148,2	1475,8	117 192	129 799
90	1185,9	1418,8	120 840	129 646
96	1284,1	1389,0	134 839	138 880
Average	2538	1651	161 723	153 534
Standard Deviation	2414,4	375	98 173	25 081
Maximum Forecast	8324	2244	442 977	207 056
Minimum Forecast	717	1147	86 882	125 094
Range	7607	1097	356 095	81 962

TABLE 1-2C : g = 0,1 D_I c 0,0

PPC	Time (Days) 02 = 0,0	Commitments (R000,s) D2 = 0,0
2	932,5	117 620
6	913,1	111 082
10	1750,4	188 751
16	1726,5	232 423
20	967,8	119 372
26	2554,2	76 962
30	4475,8	176 553
36	2442,3	860 304
40	1446,1	759 636
46	1538,9	111 218
50	2225,5	90 690
56	2993	177 819
60	2685,5	385 330
66	1348,9	542 095
70	1107,1	186 694
76	1608,8	119 121
80	2161,1	116 148
86	1882,8	127 737
90	1335,6	139 640
96	1357,1	155 489

TABLE I-3A : g = 0,05 D_I = 0,99

PPC	Time (Days)		Commitments (R000,s)	
	D2 = 0,001	D2 = 0,0001	D2 = 0,001	D2 = 0,0001
2	1349,9	1371,7	175 216	177 686
6	1263,2	1326,8	162 165	169 043
10	1236,7	1319,5	156 039	165 998
16	1209,6	1303,9	157 722	166 240
20	1183,9	1287,5	155 328	163 477
26	1325,8	1344,7	146 675	158 901
30	1417,3	1382,8	143 559	157 704
36	1535,4	1424,2	139 576	155 548
40	1655,8	1476,6	146 389	160 558
46	1839,4	1534,1	151 209	159 989
50	1944,6	1566,9	151 572	158 768
56	1990,1	1580,4	151 932	158 144
60	2018,7	1599	151 767	157 460
66	1982,7	1587,4	144 162	150 012
70	1943,8	1576,3	138 369	144 219
76	1890,4	1565,4	138 033	143 447
80	1845,3	1555,6	136 477	141 246
86	1729,9	1504,9	133 986	137 566
90	1643,0	1504,9	132 937	135 659
96	1526,7	1424,8	138 316	139 762
Average	1626	1461	147 623	155 166
Standard Deviation	296	109	10 576	11 339
Maximum Forecast	2018	1599	175 216	177 686
Minimum Forecast	1184	1287	132 937	135 659
Range	834	312	42 279	42 027

TABLE 1-3B : g = 0,05 D_I 0,90

	Time (Days)		Commitments (R000,s)	
PPC	D2 = 0,01	D2 n 0,001	D2 = 0,01	D2 = 0,001
2	1086,3	1309,3	145 033	169 731
6	722,1	1166,5	100 986	149 687
10	688,2	1142,4	89 209	141 934
16	760,8	1148,0	122 926	155 671
20	772,0	1132,4	141 429	157 803
26	2299,8	1494,0	106 829	140 769
30	4820,1	1720,1	97 632	134 546
36	9833,6	2023,9	92 110	128 356
40	9999,9	2180,7	116 662	145 384
46	7889,7	2340,2	273 813	182 875
50	5449,2	2363,7	390 368	192 529
56	2707,1	2188,7	347 974	187 033
60	2064,5	2123,1	278 616	179 895
66	1451,6	1937,4	174 674	155 333
70	1252,2	1810,2	138 770	141 282
76	1140,6	1684,2	125 697	137 443
80	1117,2	1616,4	121 252	134 855
86	1120,1	1495,5	120 224	131 777
90	1157,6	1432,1	121 956	131 034
96	1265,1	1386,1	133 786	138 084
Average	At PPC =40	1684	161 997	151 801
Standard Deviation	Time was	417	87 674	20 230
Maximum Forecast	Greater than	2363	390 368	192 529
Minimum Forecast	Formatted	1132	89 209	128 356
Range	Allowance	1231	301 159	64 173

TABLE 1-3C : g = 0,05 D1 = 0,0

PPC	Time (Days) D2 = 0,0	Commitments (R000,s) D2 = 0,0
2	932,5	117 620
6	895,3	108 984
10	1707,8	184 351
16	2083,5	255 975
20	1081,8	138 614
26	1642,5	72 692
30	2619,6	157 095
36	4141,2	999 999
40	3917,7	999 999
46	1993,1	355 258
50	1554,0	107 903
56	1308,9	107 260
60	1490,1	142 725
66	2008,7	217 327
70	2229,6	246 783
76	1763,5	187 820
80	1415,9	136 056
86	1222,8	121 321
90	1218,8	123 045
96	1395,7	149 123

TABLE 1-4A g = 0,01 D_1 = 0,99

PPC	Time (Days)		Commitments (R000,s)	
	D2 = 0,001	D2 = 0,0001	D2 = 0,001	D2 = 0,0001
2	1349,9	1371,7	175 216	177 686
6	1264,4	1326,9	162 202	169 053
10	1234,9	1319,1	156 103	166 021
16	1205,5	1302,8	157 012	166 050
20	1178,3	1286	154 610	163 292
26	1315,6	1342,3	146 810	158 952
30	1406,4	1380,3	143 947	157 833
36	1520,5	1421	140 487	155 831
40	1638,8	1473,2	146 105	160 370
46	1809,1	1528,2	147 818	158 773
50	1907	1559,0	147 918	157 508
56	1992,5	1580,0	148 780	157 094
60	2036,8	1601,8	148 902	156 528
66	2016,5	1593,9	142 273	149 453
70	1981,3	1584,0	136 951	143 828
76	1926,7	1572,9	136 926	143 146
80	1879,3	1562,5	135 594	141 006
86	1758,4	1510,5	133 414	137 408
90	1666,4	1470,1	132 542	135 548
96	1541,1	1427,8	138 061	139 640
Average	1631	1460	146 583	154 751
Standard Deviation	305	110,5	10 647	11 515
Maximum Forecast	2036	1601	175 216	177 686
Minimum Forecast	1178	1286	132 542	135 548
Range	858	315	42 674	42 138

TABLE 1-4B : g = 0,01 D_I = 0,90

PPC	Time (Days)		Commitments (R000,s)	
	D2 = 0,01	D2 = 0,001	D2 = 0,01	D2 = 0,001
2	1086,3	1309,3	145 033	169 731
6	725,7	1167,9	101 292	149 812
10	680,3	1138,1	88 521	141 545
16	745,1	1140,2	118 096	153 563
20	752,8	1121,6	137 299	156 397
26	2183,7	1474,2	112 610	142 554
30	4281,5	1687,2	103 809	136 977
36	999,9	1984,1	100 949	132 578
40	999,9	2186,0	121 220	144 381
46	999,9	2420,4	195 943	162 976
50	7681,7	2483,7	254 136	170 057
56	3511,9	2329,4	280 780	172 247
60	2491,6	2249,6	260 866	170 152
66	1606,8	2030,4	183 694	152 113
70	1333,7	1883,4	147 890	139 855
76	1176,9	1733,9	132 626	136 680
80	1145,3	1654,0	126 831	134 426
86	1135,6	1516,4	123 613	131 664
90	1157,2	1445,3	124 426	131 047
96	1246,6	1392,9	134 059	137 433
Average	Out of	1717	149 685	148 309
Standard Deviation	Formatted Range for	455	56 219	14 271
Maximum Forecast	PPC between 36 and 46	2483	280 780	172 247
Minimum Forecast		1121	88 521	131 042
Range		1362	192 259	41 205

TABLE I-4C : g = 0,01 D_I - 0,0

PPC	Time (Days) D2 = 0,0	Commitments (12000,s) D2 = 0,0
2	932,5	117 620
6	881,2	107 322
10	1676,9	181 204
16	2286,7	260 228
20	1227,1	162 128
26	1288,1	80 110
30	2142,4	128 033
36	3345,2	816 311
40	4157,3	999 999
46	3772,6	999 999
50	2399,6	244 497
56	1279,0	112 131
60	1209,0	124 707
66	1260,8	127 223
70	1349,3	117 955
76	1605,7	127 782
80	1704,1	134 259
86	1688,2	136 633
90	1595,8	135 149
96	1418,0	138 588

TABLE 1-5 $g = 0,0\ D_1 = 0,0$

PPC	Time (Days) D2 = 0,0	Commitments (R000,s) D2 = 0,0
2	1378,6	178 570
6	1346,2	171 398
10	1345,2	169 370
16	1333,0	168 955
20	1319,5	166 038
26	1347,8	163 214
30	1369,0	162 908
36	1388,2	161 700
40	1420,2	165 817
46	1443,3	162 874
50	1456,9	161 150
56	1460,5	160 443
60	1474,1	159 745
66	1468,3	152 950
70	1465,4	147 521
76	1466,4	146 781
80	1467,6	144 304
86	1438,5	140 000
90	1415,0	137 567
96	1397,5	140 745

TABLE 1-5: EFFECT OF g ON THE STANDARD DEVIATION OF TOTAL FORECASTS

g	DI		Standard Deviation	
		D2	Time	Commitments
0,01	0,99	0,001	305	10 647
0,01	0,99	0,0001	110,5	11 515
0,01	0,90	0,01	-	56 219
0,01	0,90	0,001	455	14 271
0,05	0,99	0,001	296	10 576
0,05	0,99	0,0001	109	11 339
0,05	0,90	0,01	-	87 674
0,05	0,90	0,001	417	20 230
0,10	0,99	0,001	287,0	10 978
0,10	0,99	0,0001	106,8	11 579
0,10	0,90	0,01	2414,4	98 173
0,10	0,90	0,001	375	25 081
0,30	0,99	0,001	287,3	11 150
0,30	0,99	0,0001	106,7	11 560
0,30	0,90	0,01	1509,9	56 552
0,30	0,90	0,001	376,9	17 560

FIGURE I-1

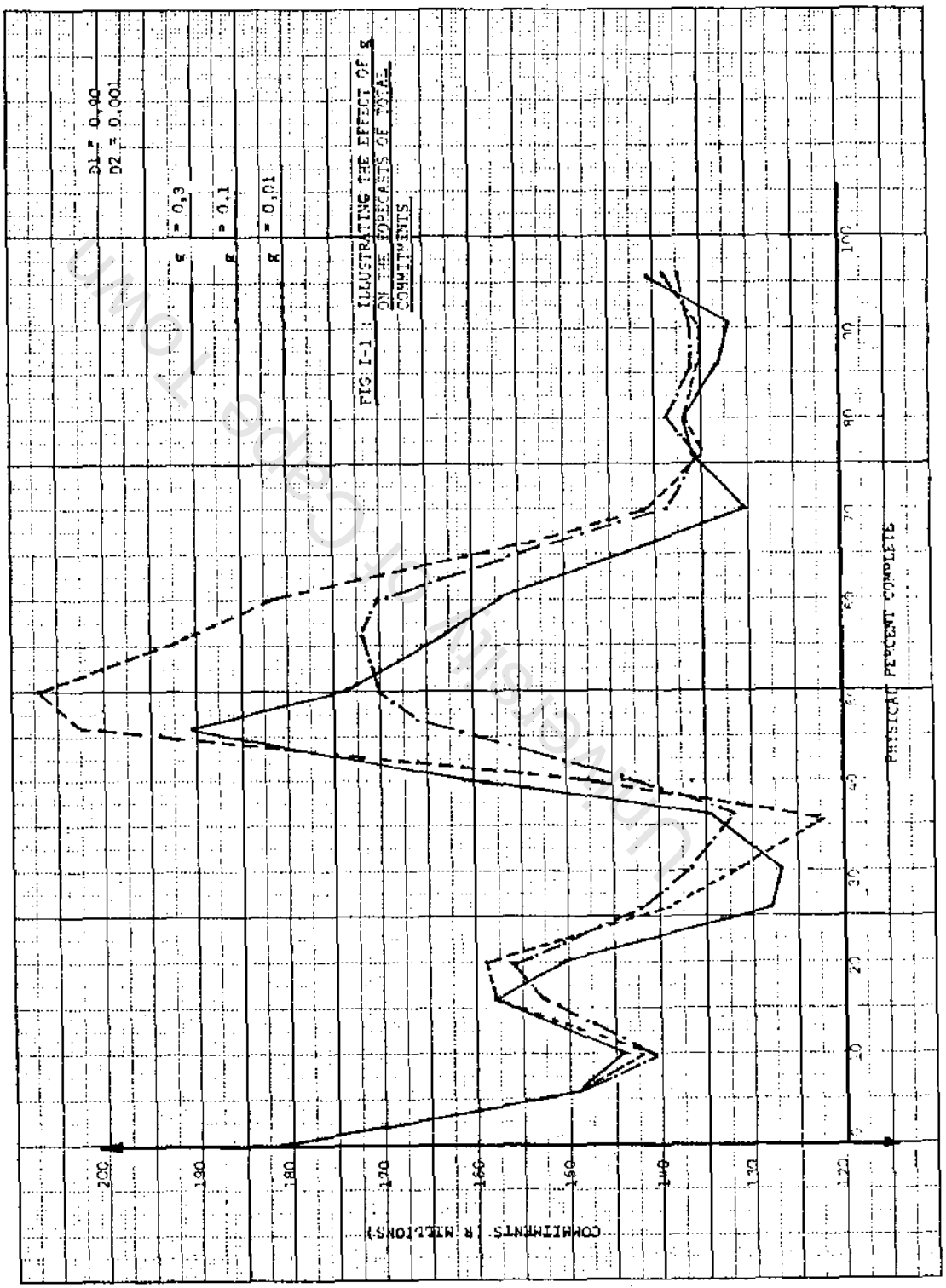


FIG I-1 : ILLUSTRATING THE EFFECT OF g ON THE FORECASTS OF TOTAL COMMITMENTS
D1 = 0,90
D2 = 0,001
g = 0,3
g = 0,1
g = 0,01
COMMITMENTS (R MILLIONS)
PHYSICAL PERCENT COMPLETE
200
190
180
170
160
150
140
130
120
100
90
80
70
60
50
40
30
20
10

FIGURE I-2

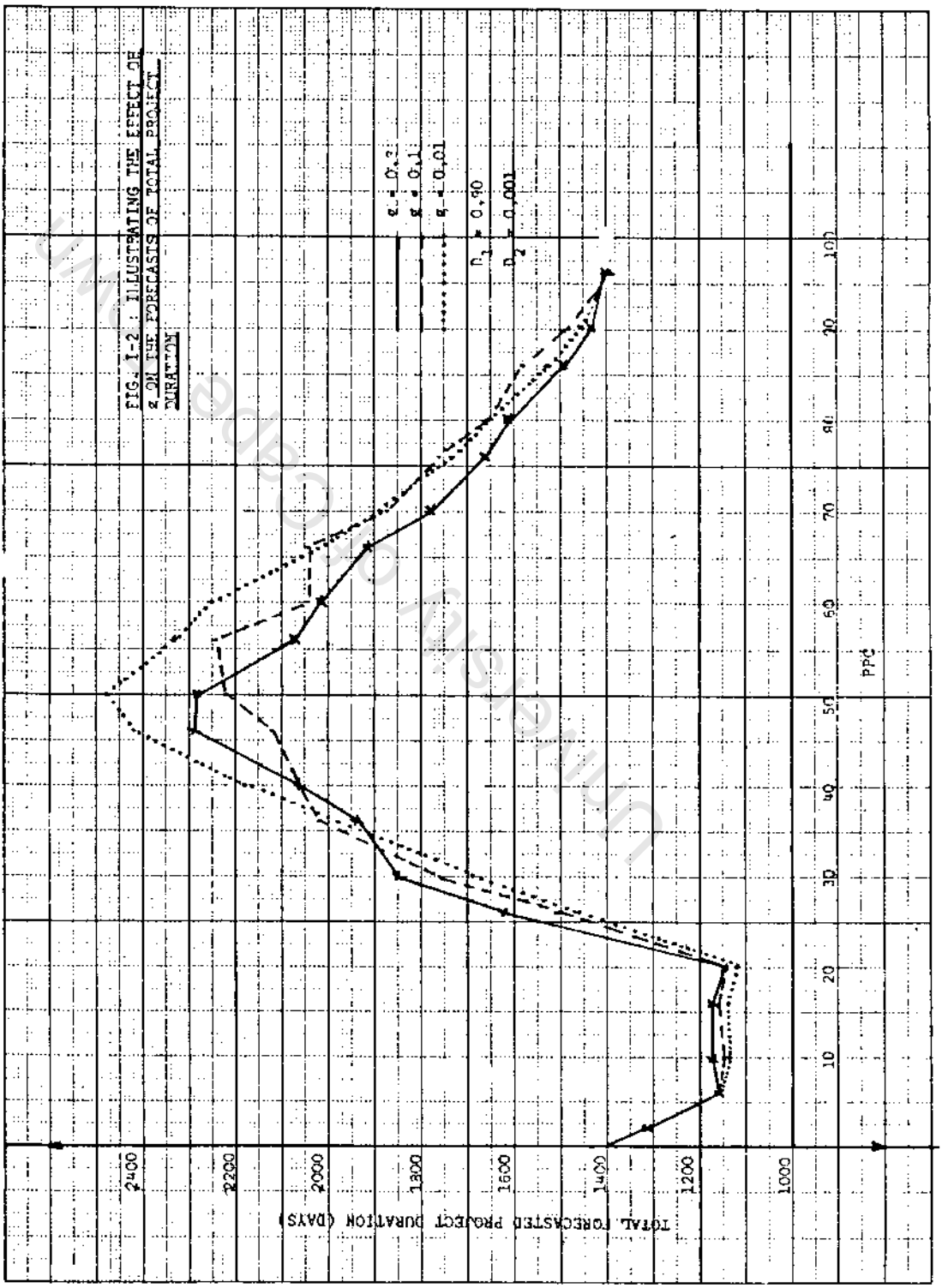


FIG. I-2 : ILLUSTRATING THE EFFECT OF
ε ON THE FORECASTS OF TOTAL PROJECT
DURATION
ε = 0.2
ε = 0.1
ε = 0.01
D1 = 0.90
D2 = 0.001
TOTAL FORECASTED PROJECT DURATION (DAYS)
2400
2200
2000
1800
1600
1400
1200
1000
10
20
30
40
50
60
70
80
90
100
PPC

FIGURE I-3

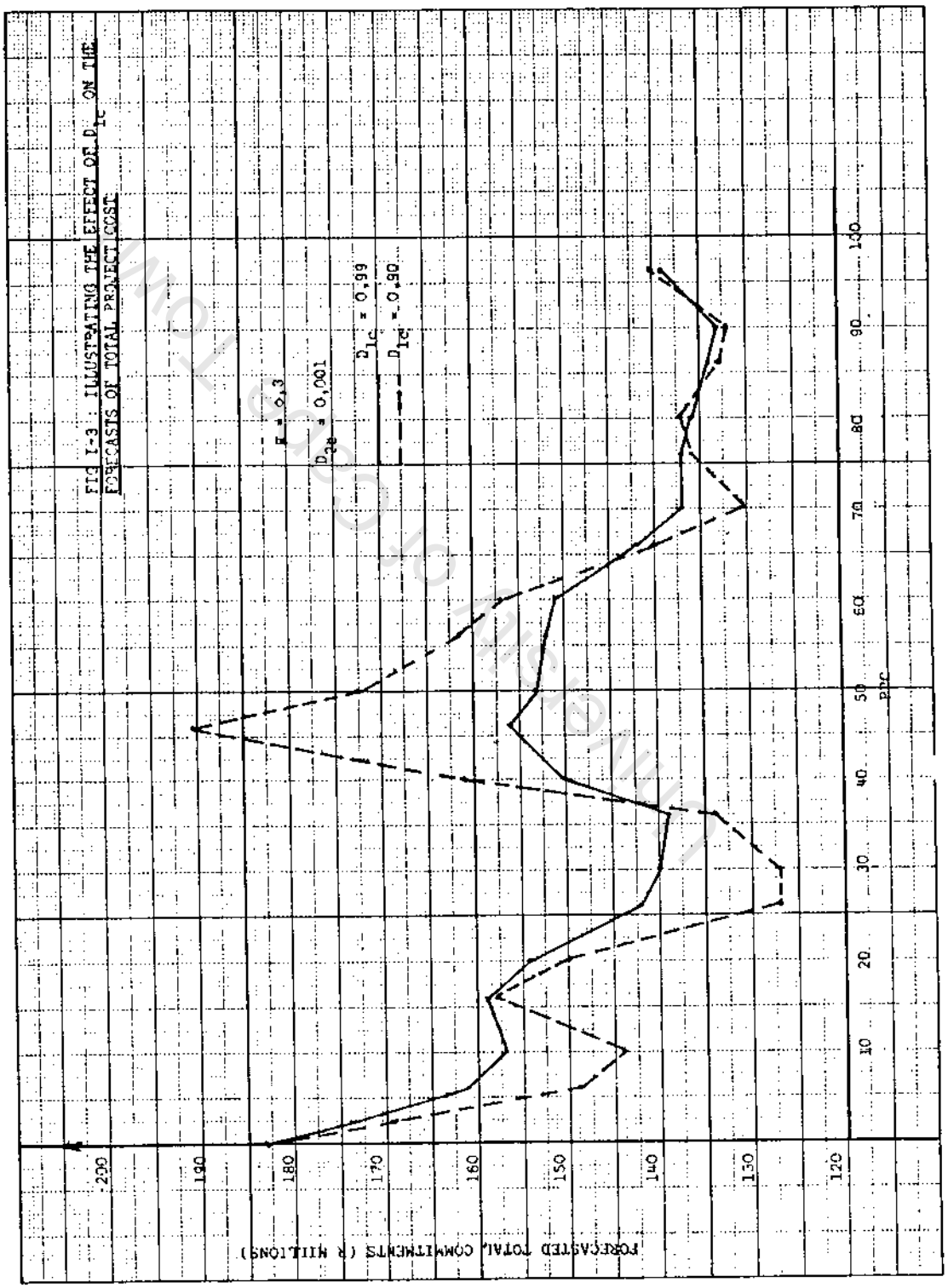


FIG I-3 : ILLUSTRATING THE EFFECT OF D_{Ic} ON THE FORECASTS OF TOTAL PROJECT COST
D_{Ic} = 0,99
D_{Ic} = 0,90
D_{3a} = 0,001
F = 0,3
FORECASTED TOTAL COMMITMENTS (R MILLIONS)
PTC
10
20
30
40
50
60
70
80
90
100
120
130
140
150
160
170
180
190
200

FIGURE I-4

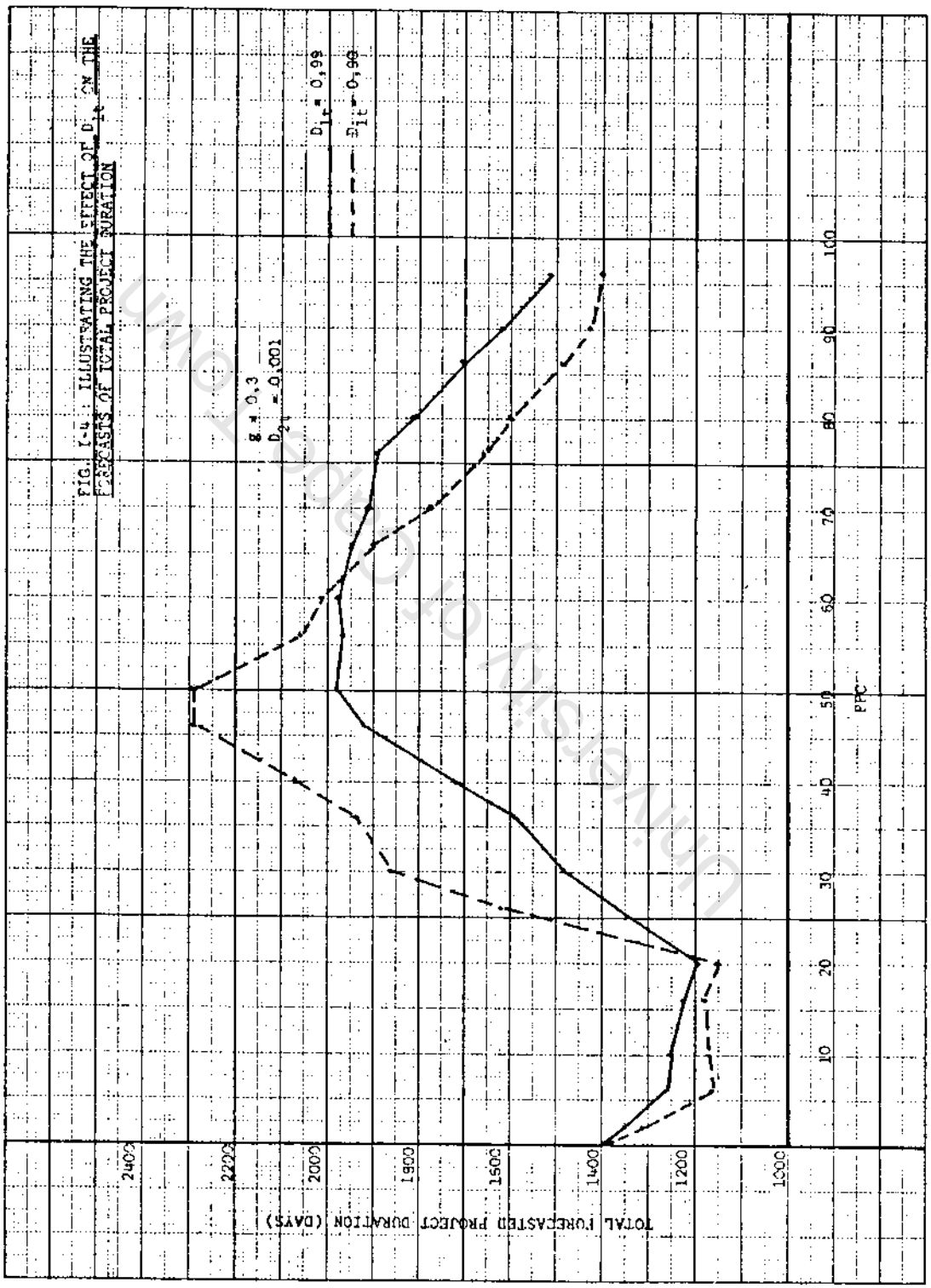


FIGURE I-5

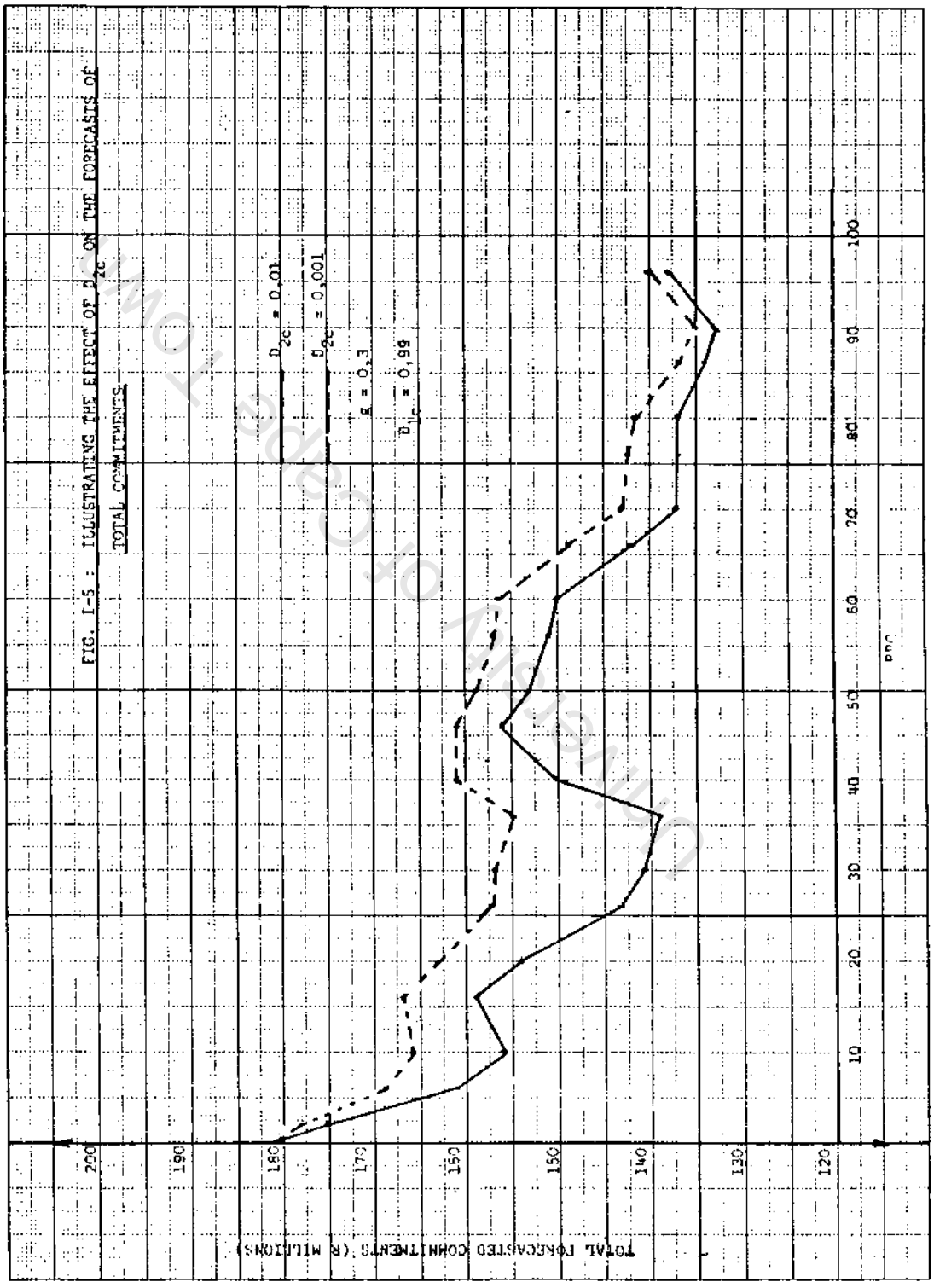


FIG. I-5 : ILLUSTRATING THE EFFECT OF D_{2c} ON THE FORECASTS OF TOTAL COMMITMENTS
D_{2c} = 0,01
D_{2c} = 0,001
α = 0,3
D_{1c} = 0,99
TOTAL FORECASTED COMMITMENTS (R MILLIONS)
200
190
180
170
160
150
140
130
120
10
20
30
40
50
60
70
80
90
100

FIGURE I-6

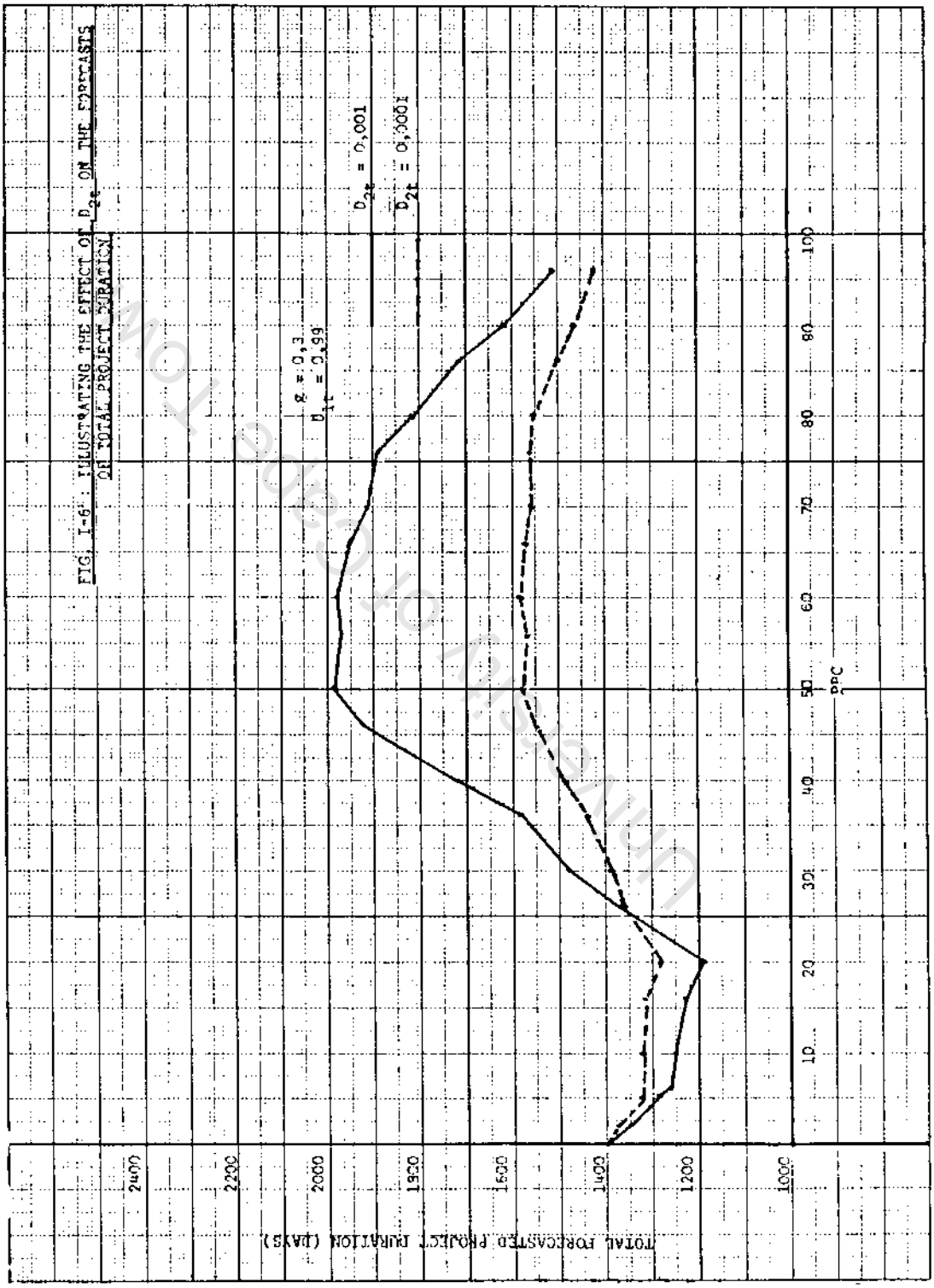


FIGURE I-7

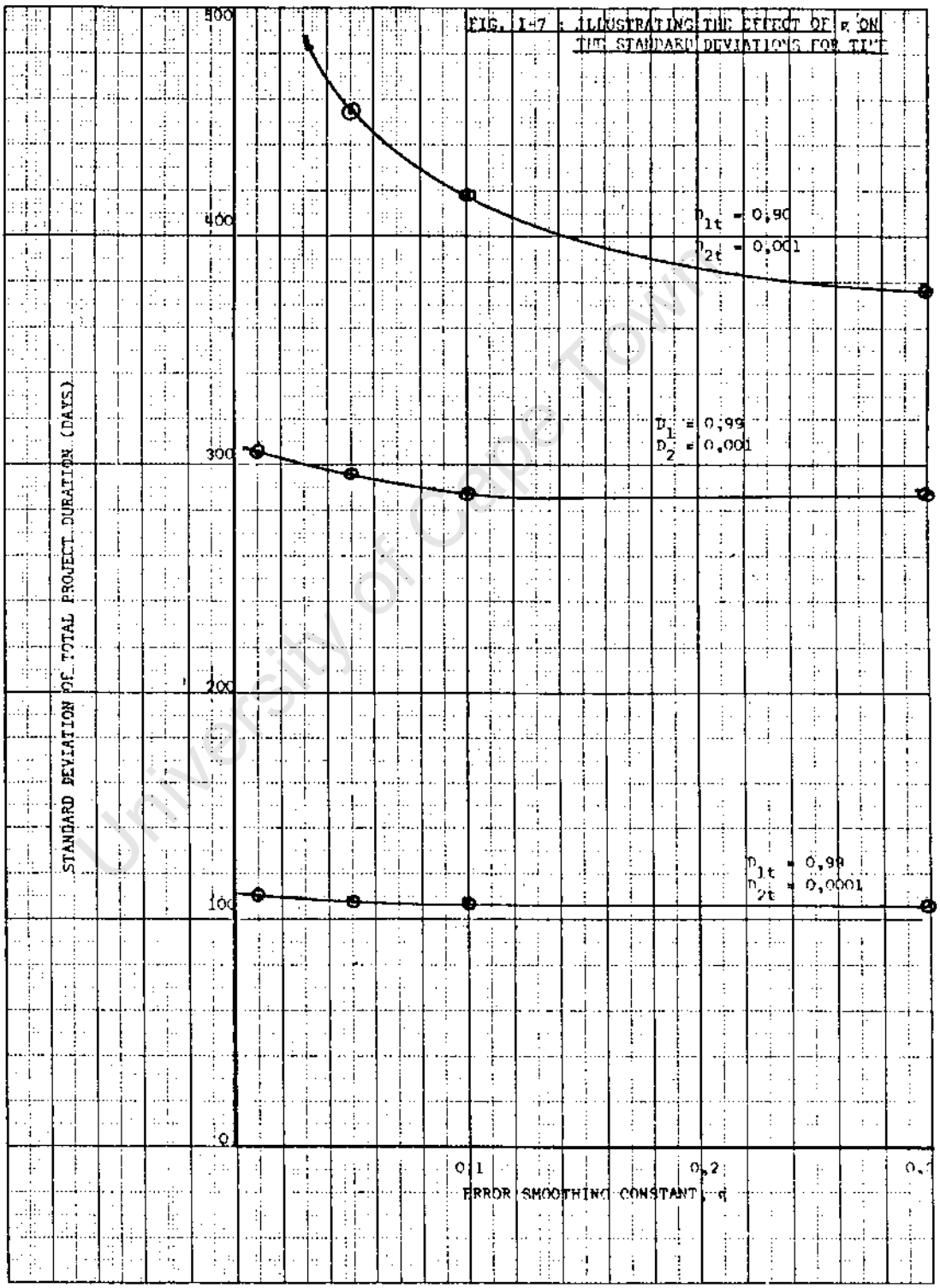


FIGURE I-8

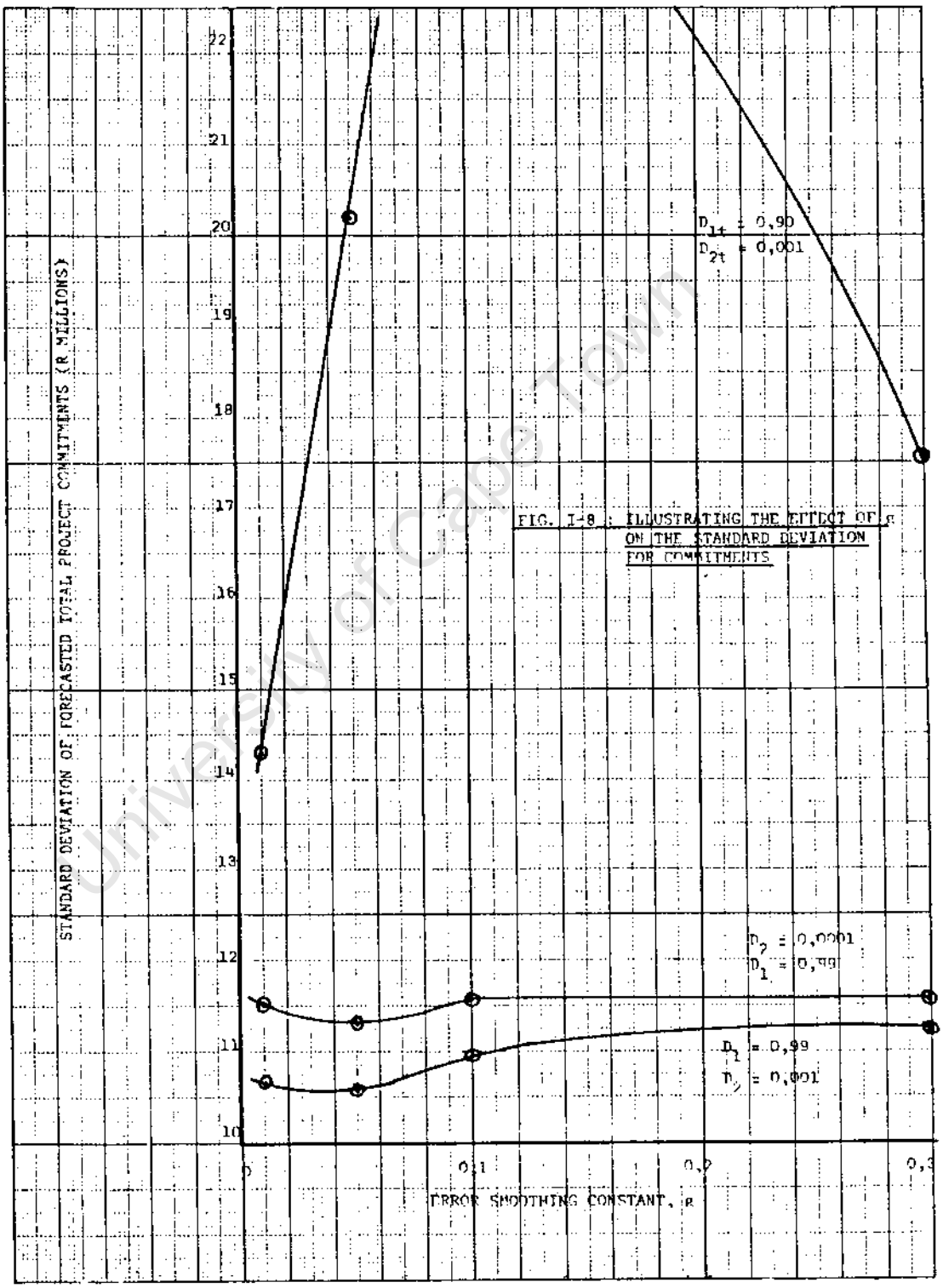


FIG. I-8 : ILLUSTRATING THE EFFECT OF α ON THE STANDARD DEVIATION FOR COMMITMENTS

APPENDIX J

RESULTS OF OBJECTIVE COMPUTER RUN

NOTE: A description of the report terminology may be found in Appendix G.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 1 SMOOTHING CONSTANTS: TIME=1.000 COST=1.000 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64.	43.	43.			-21.	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
5.0	.970	96.	160.			95.	138.	-1.	-1.00	.950	18600.	31000.			18268.	26238.	-332.	-1.79
10.0	.962	84.	244.			83.	221.	-1.	-1.29	.940	18000.	49000.			17614.	43852.	-386.	-2.14
15.0	.953	68.	312.			67.	288.	-1.	-1.57	.930	11000.	60000.			10725.	54577.	-275.	-2.50
20.0	.944	80.	392.			79.	366.	-1.	-1.85	.920	9500.	69500.			9228.	63805.	-272.	-2.86
25.0	.936	28.	420.			27.	393.	-1.	-2.14	.910	3500.	73000.			3387.	67193.	-113.	-3.22
30.0	.928	43.	463.			42.	435.	-1.	-2.42	.900	6000.	79000.			5786.	72978.	-214.	-3.57
35.0	.919	36.	499.			35.	470.	-1.	-2.70	.890	4000.	83000.			3843.	76821.	-157.	-3.93
40.0	.911	32.	531.			31.	501.	-1.	-2.99	.880	5000.	88000.			4786.	81607.	-214.	-4.29
45.0	.902	31.	562.			30.	531.	-1.	-3.27	.870	5000.	93000.			4768.	86375.	-232.	-4.64
50.0	.894	29.	591.			28.	559.	-1.	-3.56	.860	5000.	98000.			4750.	91124.	-250.	-5.00
55.0	.885	32.	623.			31.	590.	-1.	-3.84	.850	5000.	103000.			4732.	95856.	-268.	-5.36
60.0	.877	23.	646.			22.	612.	-1.	-4.12	.840	4750.	107750.			4478.	100335.	-272.	-5.72
65.0	.868	49.	695.			47.	659.	-2.	-4.41	.830	8250.	116000.			7749.	108084.	-501.	-6.07
70.0	.860	46.	741.			44.	703.	-2.	-4.69	.820	10750.	126750.			10059.	118143.	-691.	-6.43
75.0	.851	50.	791.			48.	750.	-2.	-4.98	.810	6250.	133000.			5826.	123968.	-424.	-6.79
80.0	.843	78.	869.			74.	824.	-4.	-5.26	.800	9750.	142750.			9053.	133022.	-697.	-7.15
85.0	.834	87.	956.			82.	907.	-5.	-5.54	.790	10250.	153000.			9481.	142503.	-769.	-7.50
90.0	.826	109.	1065.			103.	1009.	-6.	-5.83	.780	9500.	162500.			8753.	151256.	-747.	-7.86
95.0	.817	140.	1205.			131.	1141.	-9.	-6.11	.770	10000.	172500.			9178.	160434.	-822.	-8.22
100.0	.809	195.	1400.			183.	1323.	-12.	-6.39	.760	10500.	183000.			9600.	170034.	-900.	-8.57

SUMMARY

	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	64.0	12400.	1336.0	170600.	1400.0	183000.
ACTUAL/FORECASTED	42.6	7970.	1280.5	162064.	1323.1	170034.
VARIANCE	-21.4	-4430.	-55.5	-8536.	-76.9	-12966.
% VARIANCE	-33.4	-36.	-.4	-5.	-5.5	-7.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 2 SMOOTHING CONSTANTS: TIME=1.000 COST=1.000 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR
2.0		64.	64.	43.	43.			-21.	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128.	41.	83.			-23.	-36.25		12400.	24800.	7629.	15599.			-4771.	-38.48
5.0	.970	32.	160.			31.	115.	-1.	-2.06	.950	6200.	31000.			5976.	21574.	-224.	-3.62
10.0	.962	84.	244.			82.	197.	-2.	-2.64	.940	18000.	49000.			17219.	38793.	-781.	-4.34
15.0	.953	68.	312.			66.	262.	-2.	-3.22	.930	11000.	60000.			10444.	49238.	-556.	-5.05
20.0	.944	80.	392.			77.	339.	-3.	-3.79	.920	9500.	69500.			8953.	58191.	-547.	-5.76
25.0	.936	28.	420.			27.	366.	-1.	-4.37	.910	3500.	73000.			3274.	61464.	-226.	-6.47
30.0	.928	43.	463.			41.	407.	-2.	-4.94	.900	6000.	79000.			5569.	67034.	-431.	-7.18
35.0	.919	36.	499.			34.	441.	-2.	-5.51	.890	4000.	83000.			3685.	70718.	-315.	-7.88
40.0	.911	32.	531.			30.	471.	-2.	-6.08	.880	5000.	88000.			4571.	75290.	-429.	-8.58
45.0	.902	31.	562.			29.	500.	-2.	-6.65	.870	5000.	93000.			4536.	79826.	-464.	-9.28
50.0	.894	29.	591.			27.	527.	-2.	-7.21	.860	5000.	98000.			4501.	84327.	-499.	-9.97
55.0	.885	32.	623.			30.	556.	-2.	-7.78	.850	5000.	103000.			4467.	88794.	-533.	-10.66
60.0	.877	23.	646.			21.	577.	-2.	-8.34	.840	4750.	107750.			4211.	93005.	-539.	-11.35
65.0	.868	49.	695.			45.	622.	-4.	-8.90	.830	8250.	116000.			7257.	100262.	-993.	-12.04
70.0	.860	46.	741.			42.	664.	-4.	-9.46	.820	10750.	126750.			9382.	109644.	-1368.	-12.72
75.0	.851	50.	791.			45.	709.	-5.	-10.02	.810	6250.	133000.			5412.	115056.	-838.	-13.40
80.0	.843	78.	869.			70.	779.	-8.	-10.57	.800	9750.	142750.			8377.	123433.	-1373.	-14.08
85.0	.834	87.	956.			77.	856.	-10.	-11.13	.790	10250.	153000.			8737.	132170.	-1513.	-14.76
90.0	.826	109.	1065.			96.	952.	-13.	-11.68	.780	9500.	162500.			8034.	140204.	-1466.	-15.43
95.0	.817	140.	1205.			123.	1075.	-17.	-12.23	.770	10000.	172500.			8390.	148594.	-1610.	-16.10
100.0	.809	195.	1400.			170.	1245.	-25.	-12.78	.760	10500.	183000.			8739.	157333.	-1761.	-16.77

SUMMARY	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	128.0	24800.	1272.0	158200.	1400.0	183000.
ACTUAL/FORECASTED	83.4	15599.	1161.7	141734.	1245.1	157333.
VARIANCE	-44.6	-9201.	-110.3	-16466.	-154.9	-25667.
% VARIANCE	-34.8	-37.	-.9	-10.	-11.1	-14.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 3 SMOOTHING CONSTANTS: TIME= .018 COST= .079 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

% COMP	U/T	TIME (DAYS) BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	COMMITMENTS (R000'S) BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64.	43.	43.			-21.	-33.39		*12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128.	41.	83.			-23.	-36.25		*12400.	24800.	7629.	15599.			-4771.	-38.48
6.0		48.	176.	40.	123.			-8.	-17.56		* 9800.	34600.	7399.	22998.			-2400.	-24.49
10.0	.970	68.	244.			65.	188.	-3.	-4.80	.950	*14400.	49000.			*13527.	36525.	-873.	-6.06
15.0	.962	68.	312.			65.	253.	-3.	-4.53	.940	*11000.	60000.			*10218.	46743.	-782.	-7.11
20.0	.953	80.	392.			76.	328.	-4.	-5.39	.930	* 9500.	69500.			* 8726.	55470.	-774.	-8.14
25.0	.944	28.	420.			26.	355.	-2.	-6.24	.920	* 3500.	73000.			* 3179.	58649.	-321.	-9.17
30.0	.936	43.	463.			40.	395.	-3.	-7.09	.910	* 6000.	79000.			* 5389.	64037.	-611.	-10.19
35.0	.928	36.	499.			33.	428.	-3.	-7.93	.900	* 4000.	83000.			* 3552.	67589.	-448.	-11.20
40.0	.919	32.	531.			29.	457.	-3.	-8.76	.890	* 5000.	88000.			* 4390.	71979.	-610.	-12.21
45.0	.911	31.	562.			28.	485.	-3.	-9.59	.880	* 5000.	93000.			* 4340.	76318.	-660.	-13.21
50.0	.902	29.	591.			26.	511.	-3.	-10.42	.870	* 5000.	98000.			* 4290.	80608.	-710.	-14.20
55.0	.894	32.	623.			28.	539.	-4.	-11.24	.860	* 5000.	103000.			* 4241.	84850.	-759.	-15.18
60.0	.885	23.	646.			20.	560.	-3.	-12.06	.850	* 4750.	107750.			* 3983.	88832.	-767.	-16.15
65.0	.877	49.	695.			43.	602.	-6.	-12.87	.840	* 8250.	116000.			* 6838.	95670.	-1412.	-17.12
70.0	.868	46.	741.			40.	642.	-6.	-13.67	.830	*10750.	126750.			* 8806.	104476.	-1944.	-18.08
75.0	.860	50.	791.			43.	685.	-7.	-14.48	.820	* 6250.	133000.			* 5061.	109537.	-1189.	-19.03
80.0	.851	78.	869.			66.	751.	-12.	-15.27	.810	* 9750.	142750.			* 7802.	117339.	-1948.	-19.98
85.0	.843	87.	956.			73.	824.	-14.	-16.06	.800	*10250.	153000.			* 8106.	125446.	-2144.	-20.91
90.0	.834	*109.	1065.			91.	914.	-18.	-16.85	.790	* 9500.	162500.			* 7425.	132870.	-2075.	-21.84
95.0	.826	*140.	1205.			*115.	1030.	-25.	-17.63	.780	*10000.	172500.			* 7723.	140594.	-2277.	-22.77
100.0	.817	*195.	1400.			*159.	1189.	-36.	-18.41	.770	*10500.	183000.			* 8013.	148607.	-2487.	-23.68

SUMMARY

	TO DATE DAYS	TO DATE RANDS (000'S)	TO COMPLETION DAYS	TO COMPLETION RANDS (000'S)	TOTAL PROJECT DAYS	TOTAL PROJECT RANDS (000'S)
BUDGET	176.0	34600.	1224.0	148400.	1400.0	183000.
ACTUAL/FORECASTED	123.0	22998.	1065.9	125609.	1188.9	148607.
VARIANCE	-53.0	-11602.	-158.1	-22791.	-211.1	-34393.
% VARIANCE	-30.1	-34.	-1.3	-15.	-15.1	-19.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 4 SMOOTHING CONSTANTS: TIME= .609 COST= .505 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

% COMP	U/T	TIME (DAYS) BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	COMMITMENTS (R000'S) BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64.	43.	43.			-21.	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128.	41.	83.			-23.	-36.25		12400.	24800.	7629.	15599.			-4771.	-38.48
6.0		48.	176.	40.	123.			-8.	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34.	210.	33.	156.			-1.	-1.65		7200.	41800.	6253.	29251.			-947.	-13.15
10.0	.970	34.	244.			32.	189.	-2.	-5.14	.950	7200.	49000.			6690.	35942.	-510.	-7.08
15.0	.962	68.	312.			65.	253.	-3.	-4.96	.940	11000.	60000.			10085.	46027.	-915.	-8.32
20.0	.953	80.	392.			75.	329.	-5.	-5.91	.930	9500.	69500.			8594.	54621.	-906.	-9.54
25.0	.944	28.	420.			26.	355.	-2.	-6.85	.920	3500.	73000.			3124.	57745.	-376.	-10.75
30.0	.936	43.	463.			40.	394.	-3.	-7.79	.910	6000.	79000.			5283.	63028.	-717.	-11.94
35.0	.928	36.	499.			33.	427.	-3.	-8.71	.900	4000.	83000.			3475.	66503.	-525.	-13.13
40.0	.919	32.	531.			29.	456.	-3.	-9.63	.890	5000.	88000.			4285.	70788.	-715.	-14.30
45.0	.911	31.	562.			28.	484.	-3.	-10.55	.880	5000.	93000.			4227.	75015.	-773.	-15.46
50.0	.902	29.	591.			26.	510.	-3.	-11.45	.870	5000.	98000.			4169.	79184.	-831.	-16.61
55.0	.894	32.	623.			28.	538.	-4.	-12.35	.860	5000.	103000.			4112.	83297.	-888.	-17.75
60.0	.885	23.	646.			20.	558.	-3.	-13.25	.850	4750.	107750.			3853.	87150.	-897.	-18.88
65.0	.877	49.	695.			42.	600.	-7.	-14.14	.840	8250.	116000.			6600.	93750.	-1650.	-19.99
70.0	.868	46.	741.			39.	639.	-7.	-15.02	.830	10750.	126750.			8482.	102232.	-2268.	-21.10
75.0	.860	50.	791.			42.	681.	-8.	-15.89	.820	6250.	133000.			4863.	107095.	-1387.	-22.19
80.0	.851	78.	869.			65.	746.	-13.	-16.76	.810	9750.	142750.			7481.	114576.	-2269.	-23.27
85.0	.843	87.	956.			72.	817.	-15.	-17.62	.800	10250.	153000.			7755.	122331.	-2495.	-24.34
90.0	.834	109.	1065.			89.	906.	-20.	-18.47	.790	9500.	162500.			7087.	129418.	-2413.	-25.40
95.0	.826	140.	1205.			113.	1019.	-27.	-19.32	.780	10000.	172500.			7355.	136773.	-2645.	-26.45
100.0	.817	195.	1400.			156.	1175.	-39.	-20.17	.770	10500.	183000.			7614.	144387.	-2886.	-27.49

SUMMARY

	TO DATE DAYS	TO DATE RANDS (000'S)	TO COMPLETION DAYS	TO COMPLETION RANDS (000'S)	TOTAL PROJECT DAYS	TOTAL PROJECT RANDS (000'S)
BUDGET	210.0	41800.	1190.0	141200.	1400.0	183000.
ACTUAL/FORECASTED	156.4	29251.	1018.4	115135.	1174.8	144387.
VARIANCE	-53.6	-12549.	-171.6	-26065.	-225.2	-38613.
% VARIANCE	-25.5	-30.	-1.4	-18.	-16.1	-21.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 5 SMOOTHING CONSTANTS: TIME= .698 COST= .635 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)								COMMITMENTS (R000'S)							
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64.	43.	43.			-21.	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128.	41.	83.			-23.	-36.25		12400.	24800.	7629.	15599.			-4771.	-38.48
6.0		48.	176.	40.	123.			-8.	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34.	210.	33.	156.			-1.	-1.65		7200.	41800.	6253.	29251.			-947.	-13.15
10.0		33.	243.	33.	189.			-0.	-.82		7200.	49000.	6118.	35370.			-1082.	-15.02
15.0	.970	68.	311.			65.	254.	-3.	-5.04	.950	11000.	60000.			10018.	45388.	-982.	-8.93
20.0	.962	80.	391.			75.	329.	-5.	-6.00	.940	9500.	69500.			8525.	53913.	-975.	-10.26
25.0	.953	28.	419.			26.	355.	-2.	-6.96	.930	3500.	73000.			3095.	57008.	-405.	-11.58
30.0	.944	43.	462.			40.	395.	-3.	-7.91	.920	6000.	79000.			5227.	62235.	-773.	-12.88
35.0	.936	36.	498.			33.	427.	-3.	-8.86	.910	4000.	83000.			3433.	65668.	-567.	-14.17
40.0	.928	32.	530.			29.	456.	-3.	-9.80	.900	5000.	88000.			4228.	69896.	-772.	-15.44
45.0	.919	31.	561.			28.	484.	-3.	-10.73	.890	5000.	93000.			4165.	74061.	-835.	-16.70
50.0	.911	29.	590.			26.	510.	-3.	-11.65	.880	5000.	98000.			4103.	78163.	-897.	-17.95
55.0	.902	32.	622.			28.	538.	-4.	-12.57	.870	5000.	103000.			4041.	82204.	-959.	-19.18
60.0	.894	23.	645.			20.	557.	-3.	-13.48	.860	4750.	107750.			3781.	85986.	-969.	-20.39
65.0	.885	49.	694.			42.	599.	-7.	-14.38	.850	8250.	116000.			6468.	92454.	-1782.	-21.59
70.0	.877	46.	740.			39.	638.	-7.	-15.28	.840	10750.	126750.			8301.	100755.	-2449.	-22.78
75.0	.868	50.	790.			42.	680.	-8.	-16.17	.830	6250.	133000.			4753.	105508.	-1497.	-23.96
80.0	.860	78.	868.			65.	745.	-13.	-17.05	.820	9750.	142750.			7301.	112809.	-2449.	-25.11
85.0	.851	87.	955.			71.	816.	-16.	-17.93	.810	10250.	153000.			7558.	120367.	-2692.	-26.26
90.0	.843	109.	1064.			89.	905.	-20.	-18.80	.800	9500.	162500.			6898.	127265.	-2602.	-27.39
95.0	.834	140.	1204.			112.	1017.	-28.	-19.66	.790	10000.	172500.			7149.	134414.	-2851.	-28.51
100.0	.826	195.	1399.			155.	1172.	-40.	-20.52	.780	10500.	183000.			7390.	141805.	-3110.	-29.62

SUMMARY

	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	243.0	49000.	1156.0	134000.	1399.0	183000.
ACTUAL/FORECASTED	189.2	35370.	983.2	106435.	1172.3	141805.
VARIANCE	-53.8	-13630.	-172.8	-27565.	-226.7	-41195.
% VARIANCE	-22.2	-28.	-1.5	-21.	-16.2	-23.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 6 SMOOTHING CONSTANTS: TIME= .716 COST= .814 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)										COMMITMENTS (R000'S)									
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64.	43.	43.			-21.	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128.	41.	83.			-23.	-36.25		12400.	24800.	7629.	15599.			-4771.	-38.48
6.0		48.	176.	40.	123.			-8.	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34.	210.	33.	156.			-1.	-1.65		7200.	41800.	6253.	29251.			-947.	-13.15
10.0		33.	243.	33.	189.			-0.	-.82		7200.	49000.	6118.	35370.			-1082.	-15.02
12.0		28.	271.	26.	215.			-2.	-7.75		4400.	53400.	4830.	40200.			430.	9.78
15.0	.970	41.	312.			39.	254.	-2.	-5.52	.950	6600.	60000.			6054.	46254.	-546.	-8.28
20.0	.962	80.	392.			75.	329.	-5.	-6.03	.940	9500.	69500.			8598.	54852.	-902.	-9.49
25.0	.953	28.	420.			26.	355.	-2.	-6.99	.930	3500.	73000.			3126.	57977.	-374.	-10.70
30.0	.944	43.	463.			40.	395.	-3.	-7.95	.920	6000.	79000.			5287.	63264.	-713.	-11.89
35.0	.936	36.	499.			33.	427.	-3.	-8.90	.910	4000.	83000.			3477.	66741.	-523.	-13.07
40.0	.928	32.	531.			29.	456.	-3.	-9.85	.900	5000.	88000.			4288.	71029.	-712.	-14.24
45.0	.919	31.	562.			28.	484.	-3.	-10.78	.890	5000.	93000.			4230.	75259.	-770.	-15.40
50.0	.911	29.	591.			26.	509.	-3.	-11.71	.880	5000.	98000.			4173.	79432.	-827.	-16.55
55.0	.902	32.	623.			28.	537.	-4.	-12.63	.870	5000.	103000.			4116.	83548.	-884.	-17.68
60.0	.894	23.	646.			20.	557.	-3.	-13.55	.860	4750.	107750.			3857.	87405.	-893.	-18.81
65.0	.885	49.	695.			42.	599.	-7.	-14.46	.850	8250.	116000.			6607.	94011.	-1643.	-19.92
70.0	.877	46.	741.			39.	638.	-7.	-15.36	.840	10750.	126750.			8490.	102501.	-2260.	-21.02
75.0	.868	50.	791.			42.	680.	-8.	-16.25	.830	6250.	133000.			4868.	107369.	-1382.	-22.11
80.0	.860	78.	869.			65.	745.	-13.	-17.14	.820	9750.	142750.			7489.	114858.	-2261.	-23.19
85.0	.851	87.	956.			71.	816.	-16.	-18.02	.810	10250.	153000.			7763.	122621.	-2487.	-24.26
90.0	.843	109.	1065.			88.	904.	-21.	-18.89	.800	9500.	162500.			7094.	129715.	-2406.	-25.32
95.0	.834	140.	1205.			112.	1017.	-28.	-19.76	.790	10000.	172500.			7363.	137078.	-2637.	-26.37
100.0	.826	195.	1400.			155.	1172.	-40.	-20.62	.780	10500.	183000.			7622.	144700.	-2878.	-27.41

SUMMARY

	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	271.0	53400.	1129.0	129600.	1400.0	183000.
ACTUAL/FORECASTED	215.0	40200.	956.5	104500.	1171.5	144700.
VARIANCE	-56.0	-13200.	-172.5	-25100.	-228.5	-38300.
% VARIANCE	-20.7	-25.	-1.5	-19.	-16.3	-21.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 7 SMOOTHING CONSTANTS: TIME= .675 COST= .887 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)										COMMITMENTS (R000'S)									
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0%		64.	64.	43.	43.			-21.	-33.39%		12400.	12400.	7970.	7970.			-4430.	-35.73%
4.0%		64.	128.	41.	83.			-23.	-36.25%		12400.	24800.	7629.	15599.			-4771.	-38.48%
6.0%		48.	176.	40.	123.			-8.	-17.56%		9800.	34600.	7399.	22998.			-2400.	-24.49%
8.0%		34.	210.	33.	156.			-1.	-1.65%		7200.	41800.	6253.	29251.			-947.	-13.15%
10.0%		33.	243.	33.	189.			-0.	-.82%		7200.	49000.	6118.	35370.			-1082.	-15.02%
12.0%		28.	271.	26.	215.			-2.	-7.75%		4400.	53400.	4830.	40200.			430.	9.78%
14.0%		27.	298.	25.	240.			-2.	-5.74%		4400.	57800.	5854.	46054.			1454.	33.04%
15.0%	.970	14.	312.			13.	253.	-1.	-7.80%	.950	2200.	60000.			2060.	48113.	-140.	-6.37%
20.0%	.962	80.	392.			75.	328.	-5.	-6.07%	.940	9500.	69500.			8812.	56926.	-688.	-7.24%
25.0%	.953	28.	420.			26.	355.	-2.	-7.05%	.930	3500.	73000.			3217.	60142.	-283.	-8.10%
30.0%	.944	43.	463.			40.	394.	-3.	-8.01%	.920	6000.	79000.			5462.	65605.	-538.	-8.96%
35.0%	.936	36.	499.			33.	427.	-3.	-8.97%	.910	4000.	83000.			3607.	69212.	-393.	-9.82%
40.0%	.928	32.	531.			29.	456.	-3.	-9.93%	.900	5000.	88000.			4466.	73678.	-534.	-10.68%
45.0%	.919	31.	562.			28.	483.	-3.	-10.87%	.890	5000.	93000.			4423.	78102.	-577.	-11.53%
50.0%	.911	29.	591.			26.	509.	-3.	-11.81%	.880	5000.	98000.			4381.	82482.	-619.	-12.38%
55.0%	.902	32.	623.			28.	537.	-4.	-12.74%	.870	5000.	103000.			4338.	86821.	-662.	-13.23%
60.0%	.894	23.	646.			20.	557.	-3.	-13.66%	.860	4750.	107750.			4081.	90902.	-669.	-14.08%
65.0%	.885	49.	695.			42.	599.	-7.	-14.58%	.850	8250.	116000.			7018.	97920.	-1232.	-14.93%
70.0%	.877	46.	741.			39.	637.	-7.	-15.48%	.840	10750.	126750.			9055.	106975.	-1695.	-15.77%
75.0%	.868	50.	791.			42.	679.	-8.	-16.38%	.830	6250.	133000.			5212.	112187.	-1038.	-16.61%
80.0%	.860	78.	869.			65.	744.	-13.	-17.28%	.820	9750.	142750.			8049.	120236.	-1701.	-17.45%
85.0%	.851	87.	956.			71.	815.	-16.	-18.17%	.810	10250.	153000.			8376.	128611.	-1874.	-18.28%
90.0%	.843	109.	1065.			88.	903.	-21.	-19.05%	.800	9500.	162500.			7684.	136295.	-1816.	-19.12%
95.0%	.834	140.	1205.			112.	1015.	-28.	-19.92%	.790	10000.	172500.			8005.	144301.	-1995.	-19.95%
100.0%	.826	195.	1400.			154.	1170.	-41.	-20.78%	.780	10500.	183000.			8319.	152620.	-2181.	-20.77%

SUMMARY	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	298.0	57800.	1102.0	125200.	1400.0	183000.
ACTUAL/FORECASTED	240.4	46054.	929.3	106566.	1169.8	152620.
VARIANCE	-57.6	-11746.	-172.7	-18634.	-230.2	-30380.
% VARIANCE	-19.3	-20.	-1.6	-15.	-16.4	-17.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 8 SMOOTHING CONSTANTS: TIME= .226 COST= .303 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

TIME (DAYS)										COMMITMENTS (R000'S)								
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR
2.0		64.	64.	43.	43.			-21.	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128.	41.	83.			-23.	-36.25		12400.	24800.	7629.	15599.			-4771.	-38.48
6.0		48.	176.	40.	123.			-8.	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34.	210.	33.	156.			-1.	-1.65		7200.	41800.	6253.	29251.			-947.	-13.15
10.0		33.	243.	33.	189.			-0.	-.82		7200.	49000.	6118.	35370.			-1082.	-15.02
12.0		28.	271.	26.	215.			-2.	-7.75		4400.	53400.	4830.	40200.			430.	9.78
14.0		27.	298.	25.	240.			-2.	-5.74		4400.	57800.	5854.	46054.			1454.	33.04
16.0		30.	328.	21.	261.			-9.	-31.50		4100.	61900.	1801.	47855.			-2299.	-56.07
20.0	.970	64.	392.			60.	321.	-4.	-6.27	.950	7600.	69500.			7096.	54951.	-504.	-6.64
25.0	.962	28.	420.			26.	347.	-2.	-7.29	.940	3500.	73000.			3241.	58192.	-259.	-7.39
30.0	.953	43.	463.			39.	386.	-4.	-8.31	.930	6000.	79000.			5512.	63704.	-488.	-8.14
35.0	.944	36.	499.			33.	419.	-3.	-9.32	.920	4000.	83000.			3645.	67348.	-355.	-8.89
40.0	.936	32.	531.			29.	448.	-3.	-10.32	.910	5000.	88000.			4518.	71867.	-482.	-9.64
45.0	.928	31.	562.			27.	475.	-4.	-11.32	.900	5000.	93000.			4481.	76347.	-519.	-10.39
50.0	.919	29.	591.			25.	501.	-4.	-12.30	.890	5000.	98000.			4443.	80791.	-557.	-11.14
55.0	.911	32.	623.			28.	528.	-4.	-13.28	.880	5000.	103000.			4406.	85196.	-594.	-11.89
60.0	.902	23.	646.			20.	548.	-3.	-14.24	.870	4750.	107750.			4150.	89346.	-600.	-12.64
65.0	.894	49.	695.			42.	590.	-7.	-15.20	.860	8250.	116000.			7146.	96492.	-1104.	-13.39
70.0	.885	46.	741.			39.	628.	-7.	-16.15	.850	10750.	126750.			9230.	105722.	-1520.	-14.13
75.0	.877	50.	791.			41.	670.	-9.	-17.10	.840	6250.	133000.			5320.	111042.	-930.	-14.88
80.0	.868	78.	869.			64.	734.	-14.	-18.03	.830	9750.	142750.			8226.	119268.	-1524.	-15.63
85.0	.860	87.	956.			71.	804.	-16.	-18.96	.820	10250.	153000.			8571.	127839.	-1679.	-16.38
90.0	.851	109.	1065.			87.	891.	-22.	-19.88	.810	9500.	162500.			7873.	135712.	-1627.	-17.13
95.0	.843	140.	1205.			111.	1002.	-29.	-20.79	.800	10000.	172500.			8213.	143925.	-1787.	-17.87
100.0	.834	195.	1400.			153.	1155.	-42.	-21.69	.790	10500.	183000.			8545.	152470.	-1955.	-18.62

SUMMARY

	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	328.0	61900.	1072.0	121100.	1400.0	183000.
ACTUAL/FORECASTED	261.0	47855.	894.1	104615.	1155.1	152470.
VARIANCE	-67.0	-14045.	-177.9	-16485.	-244.9	-30530.
% VARIANCE	-20.4	-23.	-1.7	-14.	-17.5	-17.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 9 SMOOTHING CONSTANTS: TIME= .465 COST= .526 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64.	43.	43.			-21.	-33.39%		12400.	12400.	7970.	7970.			-4430.	-35.73%
4.0		64.	128.	41.	83.			-23.	-36.25%		12400.	24800.	7629.	15599.			-4771.	-38.48%
6.0		48.	176.	40.	123.			-8.	-17.56%		9800.	34600.	7399.	22998.			-2400.	-24.49%
8.0		34.	210.	33.	156.			-1.	-1.65%		7200.	41800.	6253.	29251.			-947.	-13.15%
10.0		33.	243.	33.	189.			-0.	-.82%		7200.	49000.	6118.	35370.			-1082.	-15.02%
12.0		28.	271.	26.	215.			-2.	-7.75%		4400.	53400.	4830.	40200.			430.	9.78%
14.0		27.	298.	25.	240.			-2.	-5.74%		4400.	57800.	5854.	46054.			1454.	33.04%
16.0		30.	328.	21.	261.			-9.	-31.50%		4100.	61900.	1801.	47855.			-2299.	-56.07%
18.0		32.	360.	24.	285.			-8.	-26.50%		3800.	65700.	2253.	50108.			-1547.	-40.72%
20.0	.970	32.	392.			30.	314.	-2.	-6.65%	.950	3800.	69500.			3525.	53632.	-275.	-7.25%
25.0	.962	28.	420.			26.	340.	-2.	-7.78%	.940	3500.	73000.			3216.	56848.	-284.	-8.11%
30.0	.953	43.	463.			39.	379.	-4.	-8.90%	.930	6000.	79000.			5461.	62310.	-539.	-8.98%
35.0	.944	36.	499.			32.	412.	-4.	-10.01%	.920	4000.	83000.			3606.	65916.	-394.	-9.84%
40.0	.936	32.	531.			28.	440.	-4.	-11.11%	.910	5000.	88000.			4465.	70381.	-535.	-10.70%
45.0	.928	31.	562.			27.	467.	-4.	-12.20%	.900	5000.	93000.			4422.	74803.	-578.	-11.56%
50.0	.919	29.	591.			25.	493.	-4.	-13.28%	.890	5000.	98000.			4379.	79182.	-621.	-12.42%
55.0	.911	32.	623.			27.	520.	-5.	-14.34%	.880	5000.	103000.			4337.	83519.	-663.	-13.27%
60.0	.902	23.	646.			19.	539.	-4.	-15.40%	.870	4750.	107750.			4079.	87598.	-671.	-14.12%
65.0	.894	49.	695.			41.	580.	-8.	-16.44%	.860	8250.	116000.			7015.	94613.	-1235.	-14.97%
70.0	.885	46.	741.			38.	618.	-8.	-17.48%	.850	10750.	126750.			9049.	103662.	-1701.	-15.82%
75.0	.877	50	791.			41.	659.	-9.	-18.50%	.840	6250.	133000.			5208.	108871.	-1042.	-16.67%
80.0	.868	78.	869.			63.	722.	-15.	-19.52%	.830	9750.	142750.			8043.	116914.	-1707.	-17.51%
85.0	.860	87.	956.			69.	791.	-18.	-20.52%	.820	10250.	153000.			8369.	125283.	-1881.	-18.35%
90.0	.851	109.	1065.			86.	877.	-23.	-21.52%	.810	9500.	162500.			7677.	132960.	-1823.	-19.19%
95.0	.843	140	1205.			108.	985.	-32.	-22.50%	.800	10000.	172500.			7998.	140958.	-2002.	-20.02%
100.0	.834	195	1400.			149.	1134.	-46.	-23.48%	.790	10500.	183000.			8310.	149268.	-2190.	-20.85%

SUMMARY

	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	360.0	65700.	1040.0	117300.	1400.0	183000.
ACTUAL/FORECASTED	284.5	50108.	849.8	99160.	1134.3	149268.
VARIANCE	-75.5	-15592.	-190.2	-18140.	-265.7	-33732.
% VARIANCE	-21.0	-24.	-1.8	-15.	-19.0	-18.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 10 SMOOTHING CONSTANTS: TIME= .306 COST= .594 DIT=.970 DZT=.00170 DIC=.950 DZC=.00200 G=.30

% COMP	U/T	TIME (DAYS) BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR	U/C	COMMITMENTS (R000'S) BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR
2.0*		64.	64.	43.	43.			*-21.	-33.39*		*12400.	12400.	7970.	7970.			-4430.	-35.73*
4.0*		64.	128.	41.	83.			*-23.	-36.25*		*12400.	24800.	7629.	15599.			-4771.	-38.48*
6.0*		48.	176.	40.	123.			* -8.	-17.56*		* 9800.	34600.	7399.	22998.			-2400.	-24.49*
8.0*		34.	210.	33.	156.			* -1.	-1.65*		* 7200.	41800.	6253.	29251.			-947.	-13.15*
10.0*		33.	243.	33.	189.			* -0.	-.82*		* 7200.	49000.	6118.	35370.			-1082.	-15.02*
12.0*		28.	271.	26.	215.			* -2.	-7.75*		* 4400.	53400.	4830.	40200.			430.	9.78*
14.0*		27.	298.	25.	240.			* -2.	-5.74*		* 4400.	57800.	5854.	46054.			1454.	33.04*
16.0*		30.	328.	21.	261.			* -9.	-31.50*		* 4100.	61900.	1801.	47855.			-2299.	-56.07*
18.0*		32.	360.	24.	285.			* -8.	-26.50*		* 3800.	65700.	2253.	50108.			-1547.	-40.72*
20.0*		32.	392.	27.	311.			* -5.	-15.69*		* 3800.	69500.	2431.	52538.			-1369.	-36.03*
25.0*	.970	28	420.			26.	337.	* -2.	-8.13*	.950	* 3500.	73000.			3178.	55716.	-322.	-9.20*
30.0*	.962	43.	463.			39.	376.	* -4.	-9.34*	.940	* 6000.	79000.			5384.	61100.	-616.	-10.27*
35.0*	.953	36.	499.			32.	408.	* -4.	-10.54*	.930	* 4000.	83000.			3546.	64646.	-454.	-11.34*
40.0*	.944	32.	531.			28.	437.	* -4.	-11.73*	.920	* 5000.	88000.			4380.	69027.	-620.	-12.40*
45.0*	.936	31.	562.			27.	464.	* -4.	-12.90*	.910	* 5000.	93000.			4328.	73354.	-672.	-13.45*
50.0*	.928	29.	591.			25.	489.	* -4.	-14.06*	.900	* 5000.	98000.			4275.	77629.	-725.	-14.49*
55.0*	.919	32.	623.			27.	516.	* -5.	-15.21*	.890	* 5000.	103000.			4223.	81853.	-777.	-15.53*
60.0*	.911	23.	646.			19.	535.	* -4.	-16.34*	.880	* 4750.	107750.			3963.	85816.	-787.	-16.57*
65.0*	.902	49.	695.			40.	575.	* -9.	-17.47*	.870	* 8250.	116000.			6798.	92614.	-1452.	-17.60*
70.0*	.894	46	741.			37.	613.	* -9.	-18.58*	.860	*10750.	126750.			8749.	101363.	-2001.	-18.62*
75.0*	.885	50.	791.			40.	653.	*-10.	-19.67*	.850	* 6250.	133000.			5023.	106385.	-1227.	-19.63*
80.0*	.877	78.	869.			62.	715.	*-16.	-20.76*	.840	* 9750.	142750.			7737.	114123.	-2013.	-20.64*
85.0*	.868	87.	956.			68.	783.	*-19.	-21.83*	.830	*10250.	153000.			8031.	122154.	-2219.	-21.64*
90.0*	.860	*109.	1065.			84.	867.	*-25.	-22.89*	.820	* 9500.	162500.			7349.	129503.	-2151.	-22.64*
95.0*	.851	*140.	1205.			*106.	973.	*-34.	-23.94*	.810	*10000.	172500.			7637.	137140.	-2363.	-23.63*
100.0*	.843	*195.	1400.			*146.	1120.	*-49.	-24.98*	.800	*10500.	183000.			7916.	145056.	-2584.	-24.61*

SUMMARY

	TO DATE DAYS	TO DATE RANDS (000'S)	TO COMPLETION DAYS	TO COMPLETION RANDS (000'S)	TOTAL PROJECT DAYS	TOTAL PROJECT RANDS (000'S)
BUDGET	392.0	69500.	1008.0	113500.	1400.0	183000.
ACTUAL/FORECASTED	311.5	52538.	808.1	92518.	1119.6	145056.
VARIANCE	-80.5	-16962.	-199.9	-20982.	-280.4	-37944.
% VARIANCE	-20.5	-24.	-2.0	-18.	-20.0	-21.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 11 SMOOTHING CONSTANTS: TIME= .806 COST= .743 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)										COMMITMENTS (R000'S)									
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64.	43.	43.			-21.	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128.	41.	83.			-23.	-36.25		12400.	24800.	7629.	15599.			-4771.	-38.48
6.0		48.	176.	40.	123.			-8.	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34.	210.	33.	156.			-1.	-1.65		7200.	41800.	6253.	29251.			-947.	-13.15
10.0		33.	243.	33.	189.			-0.	-.82		7200.	49000.	6118.	35370.			-1082.	-15.02
12.0		28.	271.	26.	215.			-2.	-7.75		4400.	53400.	4830.	40200.			430.	9.78
14.0		27.	298.	25.	240.			-2.	-5.74		4400.	57800.	5854.	46054.			1454.	33.04
16.0		30	328.	21.	261.			-9.	-31.50		4100.	61900.	1801.	47855.			-2299.	-56.07
18.0		32.	360.	24.	285.			-8.	-26.50		3800.	65700.	2253.	50108.			-1547.	-40.72
20.0		32.	392.	27.	311.			-5.	-15.69		3800.	69500.	2431.	52538.			-1369.	-36.03
22.0		11.	403.	24.	336.			13.	121.64		1400.	70900.	322.	52861.			-1078.	-76.98
25.0	.970	17.	420.			16.	352.	-1.	-6.27	.950	2100.	73000.			1848.	54709.	-252.	-12.00
30.0	.962	43.	463.			41.	392.	-2.	-5.58	.940	6000.	79000.			5185.	59894.	-815.	-13.59
35.0	.953	36.	499.			34.	426.	-2.	-6.00	.930	4000.	83000.			3394.	63287.	-606.	-15.16
40.0	.944	32.	531.			30.	456.	-2.	-6.44	.920	5000.	88000.			4165.	67452.	-835.	-16.71
45.0	.936	31.	562.			29.	485.	-2.	-6.89	.910	5000.	93000.			4088.	71540.	-912.	-18.24
50.0	.928	29.	591.			27.	512.	-2.	-7.34	.900	5000.	98000.			4012.	75552.	-988.	-19.76
55.0	.919	32.	623.			30.	541.	-2.	-7.80	.890	5000.	103000.			3937.	79489.	-1063.	-21.25
60.0	.911	23	646.			21.	563.	-2.	-8.26	.880	4750.	107750.			3670.	83160.	-1080.	-22.73
65.0	.902	49	695.			45.	607.	-4.	-8.74	.870	8250.	116000.			6254.	89414.	-1996.	-24.19
70.0	.894	46.	741.			42.	649.	-4.	-9.22	.860	10750.	126750.			7995.	97409.	-2755.	-25.63
75.0	.885	50	791.			45.	694.	-5.	-9.71	.850	6250.	133000.			4559.	101968.	-1691.	-27.05
80.0	.877	78.	869.			70.	764.	-8.	-10.20	.840	9750.	142750.			6975.	108943.	-2775.	-28.46
85.0	.868	87.	956.			78.	842.	-9.	-10.70	.830	10250.	153000.			7191.	116135.	-3059.	-29.84
90.0	.860	109	1065.			97.	939.	-12.	-11.20	.820	9500.	162500.			6535.	122670.	-2965.	-31.21
95.0	.851	140	1205.			124.	1062.	-16.	-11.72	.810	10000.	172500.			6744.	129414.	-3256.	-32.56
100.0	.843	195	1400.			171.	1233.	-24.	-12.23	.800	10500.	183000.			6941.	136355.	-3559.	-33.89

SUMMARY

	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	403.0	70900.	997.0	112100.	1400.0	183000.
ACTUAL/FORECASTED	335.9	52861.	897.5	83494.	1233.4	136355.
VARIANCE	-67.1	-18039.	-99.5	-28606.	-166.6	-46645.
% VARIANCE	-16.7	-25.	-1.0	-26.	-11.9	-25.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 12 SMOOTHING CONSTANTS: TIME= .438 COST= .419 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR
2.0*		64.	64.	43.	43.			*-21.	-33.39*		*12400.	12400.	7970.	7970.			-4430.	-35.73*
4.0*		64.	128.	41.	83.			*-23.	-36.25*		*12400.	24800.	7629.	15599.			-4771.	-38.48*
6.0*		48.	176.	40.	123.			* -8.	-17.56*		* 9800.	34600.	7399.	22998.			-2400.	-24.49*
8.0*		34.	210.	33.	156.			* -1.	-1.65*		* 7200.	41800.	6253.	29251.			-947.	-13.15*
10.0*		33.	243.	33.	189.			* -0.	-.82*		* 7200.	49000.	6118.	35370.			-1082.	-15.02*
12.0*		28.	271.	26.	215.			* -2.	-7.75*		* 4400.	53400.	4830.	40200.			430.	9.78*
14.0*		27.	298.	25.	240.			* -2.	-5.74*		* 4400.	57800.	5854.	46054.			1454.	33.04*
16.0*		30.	328.	21.	261.			* -9.	-31.50*		* 4100.	61900.	1801.	47855.			-2299.	-56.07*
18.0*		32.	360.	24.	285.			* -8.	-26.50*		* 3800.	65700.	2253.	50108.			-1547.	-40.72*
20.0*		32.	392.	27.	311.			* -5.	-15.69*		* 3800.	69500.	2431.	52538.			-1369.	-36.03*
22.0*		11.	403.	24.	336.			* 13.	121.64*		* 1400.	70900.	322.	52861.			-1078.	-76.98*
24.0*		11.	414.	19.	355.			* 8.	70.45*		* 1400.	72300.	747.	53608.			-652.	-46.61*
25.0*	*.970	6.	420.			* 5.	360.	* -1.	-8.98*	*.950	* 700.	73000.			* 600.	54208.	-100.	-14.30*
30.0*	*.962	43.	463.			* 42.	402.	* -1.	-2.15*	*.940	* 6000.	79000.			* 5022.	59230.	-978.	-16.30*
35.0*	*.953	36.	499.			* 35.	438.	* -1.	-1.84*	*.930	* 4000.	83000.			* 3270.	62500.	-730.	-18.26*
40.0*	*.944	32.	531.			* 32.	469.	* -0.	-1.55*	*.920	* 5000.	88000.			* 3991.	66491.	-1009.	-20.19*
45.0*	*.936	31.	562.			* 31.	500.	* -0.	-1.27*	*.910	* 5000.	93000.			* 3896.	70386.	-1104.	-22.09*
50.0*	*.928	29.	591.			* 29.	528.	* -0.	-1.01*	*.900	* 5000.	98000.			* 3803.	74189.	-1197.	-23.95*
55.0*	*.919	32.	623.			* 32.	560.	* -0.	-.77*	*.890	* 5000.	103000.			* 3711.	77900.	-1289.	-25.78*
60.0*	*.911	23.	646.			* 23.	583.	* -0.	-.53*	*.880	* 4750.	107750.			* 3440.	81340.	-1310.	-27.57*
65.0*	*.902	49.	695.			* 49.	632.	* -0.	-.32*	*.870	* 8250.	116000.			* 5830.	87170.	-2420.	-29.34*
70.0*	*.894	46.	741.			* 46.	678.	* 0.	-.12*	*.860	*10750.	126750.			* 7410.	94580.	-3340.	-31.07*
75.0*	*.885	50.	791.			* 50.	728.	* 0.	.07*	*.850	* 6250.	133000.			* 4202.	98782.	-2048.	-32.77*
80.0*	*.877	78.	869.			* 78.	806.	* 0.	.24*	*.840	* 9750.	142750.			* 6392.	105174.	-3358.	-34.44*
85.0*	*.868	87.	956.			* 87.	893.	* 0.	.40*	*.830	*10250.	153000.			* 6553.	111727.	-3697.	-36.07*
90.0*	* 860	*109.	1065.			*110.	1003.	* 1.	.54*	*.820	* 9500.	162500.			* 5921.	117647.	-3579.	-37.68*
95.0*	*.851	*140.	1205.			*141.	1144.	* 1.	.67*	*.810	*10000.	172500.			* 6075.	123722.	-3925.	-39.25*
100.0	*.843	*195.	1400.			*197.	1340.	* 2.	.78*	*.800	*10500.	183000.			* 6216.	129938.	-4284.	-40.80*

SUMMARY

	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	414.0	72300.	986.0	110700.	1400.0	183000.
ACTUAL/FORECASTED	354.6	53608.	985.7	76330.	1340.4	129938.
VARIANCE	-59.4	-18692.	-.3	-34370.	-59.6	-53062.
% VARIANCE	-14.3	-26.	.0	-31.	-4.3	-29.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 13 SMOOTHING CONSTANTS: TIME= .069 COST= .378 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64.	43.	43.			-21.	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128.	41.	83.			-23.	-36.25		12400.	24800.	7629.	15599.			-4771.	-38.48
6.0		48.	176.	40.	123.			-8.	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34.	210.	33.	156.			-1.	-1.65		7200.	41800.	6253.	29251.			-947.	-13.15
10.0		33.	243.	33.	189.			-0.	-.82		7200.	49000.	6118.	35370.			-1082.	-15.02
12.0		28.	271.	26.	215.			-2.	-7.75		4400.	53400.	4830.	40200.			430.	9.78
14.0		27.	298.	25.	240.			-2.	-5.74		4400.	57800.	5854.	46054.			1454.	33.04
16.0		30.	328.	21.	261.			-9.	-31.50		4100.	61900.	1801.	47855.			-2299.	-56.07
18.0		32.	360.	24.	285.			-8.	-26.50		3800.	65700.	2253.	50108.			-1547.	-40.72
20.0		32.	392.	27.	311			-5.	-15.69		3800.	69500.	2431.	52538.			-1369.	-36.03
22.0		11.	403.	24.	336.			13.	121.64		1400.	70900.	322.	52861.			-1078.	-76.98
24.0		11.	414.	19	355.			8.	70.45		1400.	72300.	747.	53608.			-652.	-46.61
26.0		14.	428.	22.	376.			8.	55.50		1900.	74200.	806.	54414.			-1094.	-57.59
30.0	.970	35.	463.			35.	411.	-0.	-1.19	.950	4800.	79000.			3915.	58329.	-885.	-18.44
35.0	.962	36.	499.			37.	448.	1.	1.62	.940	4000.	83000.			3169.	61498.	-831.	-20.78
40.0	.953	32.	531.			33.	480.	1.	2.68	.930	5000.	88000.			3847.	65345.	-1153.	-23.06
45.0	.944	31.	562.			32.	513.	1.	3.74	.920	5000.	93000.			3736.	69081.	-1264.	-25.28
50.0	.936	29.	591.			30.	543.	1.	4.79	.910	5000.	98000.			3627.	72708.	-1373.	-27.46
55.0	.928	32.	623.			34.	577.	2.	5.82	.900	5000.	103000.			3521.	76228.	-1479.	-29.59
60.0	.919	23.	646.			25.	601.	2.	6.84	.890	4750.	107750.			3246.	79474.	-1504.	-31.66
65.0	.911	49.	695.			53.	654.	4.	7.85	.880	8250.	116000.			5471.	84945.	-2779.	-33.69
70.0	.902	46.	741.			50.	704.	4.	8.85	.870	10750.	126750.			6916.	91861.	-3834.	-35.67
75.0	.894	50.	791.			55.	759.	5.	9.83	.860	6250.	133000.			3900.	95761.	-2350.	-37.60
80.0	.885	78.	869.			86.	846.	8.	10.80	.850	9750.	142750.			5900.	101661.	-3850.	-39.48
85.0	.877	87.	956.			97.	943.	10.	11.75	.840	10250.	153000.			6015.	107676.	-4235.	-41.32
90.0	.868	109.	1065.			123.	1066.	14.	12.69	.830	9500.	162500.			5404.	113080.	-4096.	-43.11
95.0	.860	140	1205.			159.	1225.	19.	13.62	.820	10000.	172500.			5514.	118594.	-4486.	-44.86
100.0	.851	195.	1400.			223.	1448.	28.	14.53	.810	10500.	183000.			5610.	124204.	-4890.	-46.57

SUMMARY	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	428.0	74200.	972.0	108800.	1400.0	183000.
ACTUAL/FORECASTED	376.4	54414.	1071.7	69790.	1448.1	124204.
VARIANCE	-51.6	-19786.	99.7	-39010.	48.1	-58796.
% VARIANCE	-12.1	-27.	1.0	-36.	3.4	-32.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 14 SMOOTHING CONSTANTS: TIME= .228 COST= .066 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

TIME (DAYS)											COMMITMENTS (R000'S)									
% COMP	X	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0			64.	64.	43.	43.			-21.	-33.39%		12400.	12400.	7970.	7970.			-4430.	-35.73%
4.0			64.	128.	41.	83.			-23.	-36.25%		12400.	24800.	7629.	15599.			-4771.	-38.48%
6.0			48.	176.	40.	123.			-8.	-17.56%		9800.	34600.	7399.	22998.			-2400.	-24.49%
8.0			34.	210.	33.	156.			-1.	-1.65%		7200.	41800.	6253.	29251.			-947.	-13.15%
10.0			33.	243.	33.	189.			-0.	-.82%		7200.	49000.	6118.	35370.			-1082.	-15.02%
12.0			28.	271.	26.	215.			-2.	-7.75%		4400.	53400.	4830.	40200.			430.	9.78%
14.0			27.	298.	25.	240.			-2.	-5.74%		4400.	57800.	5854.	46054.			1454.	33.04%
16.0			30.	328.	21.	261.			-9.	-31.50%		4100.	61900.	1801.	47855.			-2299.	-56.07%
18.0			32.	360.	24.	285.			-8.	-26.50%		3800.	65700.	2253.	50108.			-1547.	-40.72%
20.0			32.	392.	27.	311.			-5.	-15.69%		3800.	69500.	2431.	52538.			-1369.	-36.03%
22.0			11.	403.	24.	336.			13.	121.64%		1400.	70900.	322.	52861.			-1078.	-76.98%
24.0			11.	414.	19.	355.			8.	70.45%		1400.	72300.	747.	53608.			-652.	-46.61%
26.0			14.	428.	22.	376.			8.	55.50%		1900.	74200.	806.	54414.			-1094.	-57.59%
28.0			17.	445.	26.	403.			9.	55.00%		2400.	76600.	1514.	55928.			-885.	-36.90%
30.0	.970		18.	463.			18.	420.	-0.	-1.55%	.950	2400.	79000.			1909.	57838.	-491.	-20.46%
35.0	.962		36.	499.			38.	458.	2.	4.85%	.940	4000.	83000.			3075.	60913.	-925.	-23.13%
40.0	.953		32.	531.			34.	492.	2.	6.67%	.930	5000.	88000.			3714.	64627.	-1286.	-25.72%
45.0	.944		31.	562.			34.	526.	3.	8.50%	.920	5000.	93000.			3588.	68215.	-1412.	-28.24%
50.0	.936		29.	591			32.	558.	3.	10.33%	.910	5000.	98000.			3466.	71680.	-1534.	-30.69%
55 0	.928		32.	623			36.	594.	4.	12.16%	.900	5000.	103000.			3347.	75027.	-1653.	-33.07%
60.0	.919		23.	646.			26.	620.	3.	13.99%	.890	4750.	107750.			3070.	78097.	-1680.	-35.38%
65.0	.911		49.	695			57.	677.	8.	15.83%	.880	8250.	116000.			5146.	83243.	-3104.	-37.62%
70.0	.902		46.	741.			54.	731.	8.	17.66%	.870	10750.	126750.			6472.	89715.	-4278.	-39.80%
75.0	.894		50.	791			60.	791.	10.	19.49%	.860	6250.	133000.			3630.	93345.	-2620.	-41.92%
80.0	.885		78.	869.			95.	885.	17.	21.33%	.850	9750.	142750.			5463.	98808.	-4287.	-43.97%
85.0	.877		87.	956.			107.	992.	20.	23.16%	.840	10250.	153000.			5539.	104347.	-4711.	-45.96%
90 0	.868		109.	1065			136.	1129.	27.	24.98%	.830	9500.	162500.			4950.	109297.	-4550.	-47.89%
95 0	.860		140.	1205			178.	1306.	38.	26.81%	.820	10000.	172500.			5023.	114320.	-4977.	-49.77%
100.0	.851		195.	1400			251.	1557.	56.	28.63%	.810	10500.	183000.			5083.	119404.	-5417.	-51.59%

SUMMARY

	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	445.0	76600.	955.0	106400.	1400.0	183000.
ACTUAL/FORECASTED	402.7	55928.	1154.3	63475.	1557.1	119404.
VARIANCE	-42.3	-20672.	199.3	-42925.	157.1	-63596.
% VARIANCE	-9.5	-27.	2.1	-40.	11.2	-35.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 15 SMOOTHING CONSTANTS: TIME= .345 COST= .653 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

		TIME (DAYS)										COMMITMENTS (R000'S)							
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR
2.0*		64.	64.	43.	43.			*-21.	-33.39*		*12400.	12400.	7970.	7970.			-4430.	-35.73*
4.0*		64.	128.	41.	83.			*-23.	-36.25*		*12400.	24800.	7629.	15599.			-4771.	-38.48*
6.0*		48.	176.	40.	123.			*-8.	-17.56*		*9800.	34600.	7399.	22998.			-2400.	-24.49*
8.0*		34.	210.	33.	156.			*-1.	-1.65*		*7200.	41800.	6253.	29251.			-947.	-13.15*
10.0*		33.	243.	33.	189.			*-0.	-.82*		*7200.	49000.	6118.	35370.			-1082.	-15.02*
12.0*		28.	271.	26.	215.			*-2.	-7.75*		*4400.	53400.	4830.	40200.			430.	9.78*
14.0*		27.	298.	25.	240.			*-2.	-5.74*		*4400.	57800.	5854.	46054.			1454.	33.04*
16.0*		30.	328.	21.	261.			*-9.	-31.50*		*4100.	61900.	1801.	47855.			-2299.	-56.07*
18.0*		32.	360.	24.	285.			*-8.	-26.50*		*3800.	65700.	2253.	50108.			-1547.	-40.72*
20.0*		32.	392.	27.	311.			*-5.	-15.69*		*3800.	69500.	2431.	52538.			-1369.	-36.03*
22.0*		11.	403.	24.	336.			*13.	121.64*		*1400.	70900.	322.	52861.			-1078.	-76.98*
24.0*		11.	414.	19.	355.			*8.	70.45*		*1400.	72300.	747.	53608.			-652.	-46.61*
26.0*		14.	428.	22.	376.			*8.	55.50*		*1900.	74200.	806.	54414.			-1094.	-57.59*
28.0*		17.	445.	26.	403.			*9.	55.00*		*2400.	76600.	1514.	55928.			-885.	-36.90*
30.0*		17.	462.	29.	432.			*12.	72.06*		*2400.	79000.	2980.	58908.			580.	24.16*
35.0*	.970	36.	498.			39.	471.	3.	7.26*	.950	4000.	83000.			3105.	62013.	-895.	-22.38*
40.0*	.962	32.	530.			35.	506.	3.	9.82*	.940	5000.	88000.			3758.	65771.	-1242.	-24.85*
45.0*	.953	31.	561.			35.	541.	4.	12.40*	.930	5000.	93000.			3637.	69408.	-1363.	-27.26*
50.0*	.944	29.	590.			33.	574.	4.	15.02*	.920	5000.	98000.			3520.	72928.	-1480.	-29.60*
55.0*	.936	32.	622.			38.	612.	6.	17.66*	.910	5000.	103000.			3405.	76333.	-1595.	-31.89*
60.0*	.928	23.	645.			28.	639.	5.	20.32*	.900	4750.	107750.			3130.	79463.	-1620.	-34.12*
65.0*	.919	49.	694.			60.	700.	11.	23.01*	.890	8250.	116000.			5257.	84720.	-2993.	-36.28*
70.0*	.911	46.	740.			58.	757.	12.	25.72*	.880	*10750.	126750.			6623.	91343.	-4127.	-38.39*
75.0*	.902	50.	790.			64.	822.	14.	28.46*	.870	6250.	133000.			3722.	95065.	-2528.	-40.44*
80.0*	.894	78.	868.			*102.	924.	24.	31.22*	.860	9750.	142750.			5612.	100677.	-4138.	-42.44*
85.0*	.885	87.	955.			*117.	1041.	30.	34.00*	.850	*10250.	153000.			5701.	106379.	-4549.	-44.38*
90.0*	.877	*109.	1064.			*149.	1190.	40.	36.80*	.840	9500.	162500.			5105.	111483.	-4395.	-46.27*
95.0*	.868	*140	1204.			*195.	1385.	55.	39.63*	.830	*10000.	172500.			5190.	116673.	-4810.	-48.10*
100.0	.860	*195.	1399.			*278.	1663.	83.	42.47*	.820	*10500.	183000.			5262.	121935.	-5238.	-49.89*

SUMMARY	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	462.0	79000.	937.0	104000.	1399.0	183000.
ACTUAL/FORECASTED	432.0	58908.	1231.0	63027.	1663.0	121935.
VARIANCE	-30.0	-20092.	294.0	-40973.	264.0	-61065.
% VARIANCE	-6.5	-25.	3.1	-39.	18.9	-33.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 16 SMOOTHING CONSTANTS: TIME= .480 COST= .662 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR
2.0		64.	64.	43.	43.			-21.	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128.	41.	83.			-23.	-36.25		12400.	24800.	7629.	15599.			-4771.	-38.48
6.0		48.	176.	40	123.			-8.	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34.	210.	33.	156.			-1.	-1.65		7200.	41800.	6253.	29251.			-947.	-13.15
10.0		33.	243.	33.	189.			-0.	-.82		7200.	49000.	6118.	35370.			-1082.	-15.02
12.0		28.	271.	26.	215.			-2.	-7.75		4400.	53400.	4830.	40200.			430.	9.78
14.0		27.	298.	25.	240.			-2.	-5.74		4400.	57800.	5854.	46054.			1454.	33.04
16.0		30.	328.	21.	261.			-9.	-31.50		4100.	61900.	1801.	47855.			-2299.	-56.07
18.0		32.	360.	24.	285.			-8.	-26.50		3800.	65700.	2253.	50108.			-1547.	-40.72
20.0		32.	392.	27.	311.			-5.	-15.69		3800.	69500.	2431.	52538.			-1369.	-36.03
22.0		11.	403	24.	336.			13.	121.64		1400.	70900.	322.	52861.			-1078.	-76.98
24.0		11.	414	19	355.			8.	70.45		1400.	72300.	747.	53608.			-652.	-46.61
26.0		14.	428.	22.	376.			8.	55.50		1900.	74200.	806.	54414.			-1094.	-57.59
28.0		17	445	26	403			9.	55.00		2400.	76600.	1514.	55928.			-885.	-36.90
30.0		17.	462.	29.	432.			12.	72.06		2400.	79000.	2980.	58908.			580.	24.16
32.0		15.	477.	24.	456.			9.	60.00		1600.	80600.	1522.	60430.			-78.	-4.90
35.0	.970	22.	499.			24.	480.	2.	7.40	.950	2400.	83000.			1883.	62313.	-517.	-21.54
40.0	.962	32.	531.			36.	516.	4.	12.62	.940	5000.	88000.			3806.	66119.	-1194.	-23.88
45.0	.953	31.	562.			36.	552.	5.	15.91	.930	5000.	93000.			3692.	69811.	-1308.	-26.16
50.0	.944	29.	591.			35.	586.	6.	19.26	.920	5000.	98000.			3580.	73391.	-1420.	-28.39
55.0	.936	32.	623.			39.	625.	7.	22.66	.910	5000.	103000.			3471.	76863.	-1529.	-30.57
60.0	.928	23.	646.			29.	654.	6.	26.11	.900	4750.	107750.			3197.	80059.	-1553.	-32.70
65.0	.919	49.	695			64.	718.	15.	29.63	.890	8250.	116000.			5381.	85440.	-2869.	-34.78
70.0	.911	46.	741.			61.	779.	15.	33.19	.880	10750.	126750.			6794.	92234.	-3956.	-36.80
75.0	.902	50.	791.			68.	848.	18.	36.82	.870	6250.	133000.			3826.	96061.	-2424.	-38.78
80.0	.894	78.	869.			110.	957.	32.	40.50	.860	9750.	142750.			5781.	101842.	-3969.	-40.71
85.0	.885	87.	956.			125.	1083.	38.	44.23	.850	10250.	153000.			5885.	107727.	-4365.	-42.59
90.0	.877	109.	1065.			161.	1244.	52.	48.02	.840	9500.	162500.			5280.	113007.	-4220.	-44.42
95.0	.868	140	1205.			213.	1457.	73.	51.86	.830	10000.	172500.			5379.	118387.	-4621.	-46.21
100.0	.860	195.	1400			304.	1760.	109.	55.76	.820	10500.	183000.			5466.	123852.	-5034.	-47.95

SUMMARY

	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	477.0	80600.	923.0	102400.	1400.0	183000.
ACTUAL/FORECASTED	456.0	60430.	1304.4	63422.	1760.4	123852.
VARIANCE	-21.0	-20170.	381.4	-38978.	360.4	-59148.
% VARIANCE	-4.4	-25.	4.1	-38.	25.7	-32.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 17 SMOOTHING CONSTANTS: TIME= .686 COST= .164 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 C=.30

	TIME (DAYS)									COMMITMENTS (R000'S)							
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64.	43.	43.			-21.	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128.	41.	83.			-23.	-36.25		12400.	24800.	7629.	15599.			-4771.	-38.48
6.0		48.	176.	40.	123.			-8.	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34.	210.	33.	156.			-1.	-1.65		7200.	41800.	6253.	29251.			-947.	-13.15
10.0		33.	243.	33.	189.			-0.	-.82		7200.	49000.	6118.	35370.			-1082.	-15.02
12.0		28.	271.	26.	215.			-2.	-7.75		4400.	53400.	4830.	40200.			430.	9.78
14.0		27.	298.	25.	240.			-2.	-5.74		4400.	57800.	5854.	46054.			1454.	33.04
16.0		30.	328.	21.	261.			-9.	-31.50		4100.	61900.	1801.	47855.			-2299.	-56.07
18.0		32.	360.	24.	285.			-8.	-26.50		3800.	65700.	2253.	50108.			-1547.	-40.72
20.0		32.	392.	27.	311.			-5.	-15.69		3800.	69500.	2431.	52538.			-1369.	-36.03
22.0		11.	403.	24.	336.			13.	121.64		1400.	70900.	322.	52861.			-1078.	-76.98
24.0		11.	414.	19.	355.			8.	70.45		1400.	72300.	747.	53608.			-652.	-46.61
26.0		14	428.	22.	376.			8.	55.50		1900.	74200.	806.	54414.			-1094.	-57.59
28.0		17.	445.	26.	403.			9.	55.00		2400.	76600.	1514.	55928.			-885.	-36.90
30.0		17.	462.	29.	432			12.	72.06		2400.	79000.	2980.	58908.			580.	24.16
32.0		15.	477.	24.	456.			9.	60.00		1600.	80600.	1522.	60430.			-78.	-4.90
34.0		14.	491.	19.	475.			5.	34.21		1600.	82200.	1073.	61503.			-527.	-32.95
35.0	.970	8.	499.			8.	483.	0.	-.54	.950	800.	83000.			633.	62135.	-167.	-20.93
40.0	.962	32.	531.			37.	519.	5.	14.10	.940	5000.	88000.			3842.	65977.	-1158.	-23.17
45.0	.953	31.	562.			37.	556.	6.	17.77	.930	5000.	93000.			3732.	69709.	-1268.	-25.36
50 0	.944	29.	591.			35.	591.	6.	21.51	.920	5000.	98000.			3625.	73334.	-1375.	-27.50
55.0	.936	32.	623.			40.	631.	8.	25.33	.910	5000.	103000.			3520.	76854.	-1480.	-29.60
60.0	.928	23.	646.			30.	661.	7.	29.23	.900	4750.	107750.			3247.	80101.	-1503.	-31.65
65.0	.919	49.	695.			65.	726.	16.	33.20	.890	8250.	116000.			5473.	85574.	-2777.	-33.66
70.0	.911	46.	741.			63.	789.	17.	37.26	.880	10750.	126750.			6921.	92495.	-3829.	-35.62
75.0	.902	50.	791.			71.	860.	21.	41.39	.870	6250.	133000.			3904.	96399.	-2346.	-37.54
80.0	.894	78.	869.			114.	973.	36.	45.60	.860	9750.	142750.			5907.	102306.	-3843.	-39.41
85 0	885	87.	956			130.	1104.	43.	49.88	.850	10250.	153000.			6023.	108329.	-4227.	-41.24
90.0	.877	109.	1065.			168.	1272.	59.	54.25	.840	9500.	162500.			5412.	113740.	-4088.	-43.03
95.0	.868	140	1205.			222.	1494.	82.	58.69	.830	10000.	172500.			5522.	119262.	-4478.	-44.78
100.0	860	195.	1400			318.	1812.	123.	63.22	.820	10500.	183000.			5619.	124881.	-4881.	-46.49

SUMMARY

	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	491.0	82200.	909.0	100800.	1400.0	183000.
ACTUAL/FORECASTED	474.8	61503.	1337.7	63378.	1812.5	124881.
VARIANCE	-16.2	-20697.	428.7	-37422.	412.5	-58119.
% VARIANCE	-3.3	-25.	4.7	-37.	29.5	-32.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 18 SMOOTHING CONSTANTS: TIME= .723 COST= .142 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
X COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64.	43.	43.			-21.	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128.	41.	83.			-23.	-36.25		12400.	24800.	7629.	15599.			-4771.	-38.48
6.0		48.	176.	40.	123.			-8.	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34.	210.	33.	156.			-1.	-1.65		7200.	41800.	6253.	29251.			-947.	-13.15
10.0		33.	243.	33.	189.			-0.	-.82		7200.	49000.	6118.	35370.			-1082.	-15.02
12.0		28.	271.	26.	215.			-2.	-7.75		4400.	53400.	4830.	40200.			430.	9.78
14.0		27.	298.	25.	240.			-2.	-5.74		4400.	57800.	5854.	46054.			1454.	33.04
16.0		30.	328.	21.	261.			-9.	-31.50		4100.	61900.	1801.	47855.			-2299.	-56.07
18.0		32.	360.	24.	285.			-8.	-26.50		3800.	65700.	2253.	50108.			-1547.	-40.72
20.0		32.	392.	27.	311.			-5.	-15.69		3800.	69500.	2431.	52538.			-1369.	-36.03
22.0		11.	403.	24.	336.			13.	121.64		1400.	70900.	322.	52861.			-1078.	-76.98
24.0		11.	414.	19.	355.			8.	70.45		1400.	72300.	747.	53608.			-652.	-46.61
26.0		14.	428.	22.	376.			8.	55.50		1900.	74200.	806.	54414.			-1094.	-57.59
28.0		17.	445.	26.	403.			9.	55.00		2400.	76600.	1514.	55928.			-885.	-36.90
30.0		17.	462.	29.	432.			12.	72.06		2400.	79000.	2980.	58908.			580.	24.16
32.0		15.	477.	24.	456.			9.	60.00		1600.	80600.	1522.	60430.			-78.	-4.90
34.0		14.	491.	19.	475.			5.	34.21		1600.	82200.	1073.	61503.			-527.	-32.95
36.0		14.	505.	19.	494.			5.	34.07		1800.	84000.	1198.	62700.			-602.	-33.46
40.0	.970	26.	531.			29.	523.	3.	13.22	.950	4000.	88000.			3091.	65791.	-909.	-22.73
45.0	.962	31.	562.			37.	560.	6.	18.95	.940	5000.	93000.			3757.	69549.	-1243.	-24.85
50.0	.953	29.	591.			36.	596.	7.	23.00	.930	5000.	98000.			3654.	73202.	-1346.	-26.93
55.0	.944	32.	623.			41.	636.	9.	27.14	.920	5000.	103000.			3552.	76754.	-1448.	-28.96
60.0	.936	23.	646.			30.	666.	7.	31.38	.910	4750.	107750.			3280.	80034.	-1470.	-30.96
65.0	.928	49.	695.			67.	733.	18.	35.72	.900	8250.	116000.			5535.	85569.	-2715.	-32.91
70.0	.919	46.	741.			64.	797.	18.	40.15	.890	10750.	126750.			7007.	92576.	-3743.	-34.82
75.0	.911	50.	791.			72.	870.	22.	44.69	.880	6250.	133000.			3957.	96533.	-2293.	-36.69
80.0	.902	78.	869.			116.	986.	38.	49.31	.870	9750.	142750.			5994.	102527.	-3756.	-38.52
85.0	.894	87.	956.			134.	1120.	47.	54.04	.860	10250.	153000.			6118.	108645.	-4132.	-40.31
90.0	.885	109.	1065.			173.	1293.	64.	58.87	.850	9500.	162500.			5504.	114148.	-3996.	-42.07
95.0	.877	140	1205.			229.	1523.	89.	63.80	.840	10000.	172500.			5622.	119770.	-4378.	-43.78
100.0	.868	175.	1400.			329.	1852.	134.	68.83	.830	10500.	183000.			5727.	125497.	-4773.	-45.46

SUMMARY

	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	505.0	84000.	895.0	99000.	1400.0	183000.
ACTUAL/FORECASTED	493.6	62700.	1358.4	62796.	1852.0	125497.
VARIANCE	-11.4	-21300.	463.4	-36204.	452.0	-57503.
% VARIANCE	-2.3	-25.	5.2	-37.	32.3	-31.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 19 SMOOTHING CONSTANTS: TIME= .689 COST= .305 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64.	43.	43.			-21.	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128.	41.	83.			-23.	-36.25		12400.	24800.	7629.	15599.			-4771.	-38.48
6.0		48.	176.	40.	123.			-8.	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34.	210.	33.	156.			-1.	-1.65		7200.	41800.	6253.	29251.			-947.	-13.15
10.0		33.	243.	33.	189.			-0.	-.82		7200.	49000.	6118.	35370.			-1082.	-15.02
12.0		28.	271.	26.	215.			-2.	-7.75		4400.	53400.	4830.	40200.			430.	9.78
14.0		27.	298.	25.	240.			-2.	-5.74		4400.	57800.	5854.	46054.			1454.	33.04
16.0		30.	328.	21.	261.			-9.	-31.50		4100.	61900.	1801.	47855.			-2299.	-56.07
18.0		32.	360.	24.	285.			-8.	-26.50		3800.	65700.	2253.	50108.			-1547.	-40.72
20.0		32.	392.	27.	311.			-5.	-15.69		3800.	69500.	2431.	52538.			-1369.	-36.03
22.0		11.	403.	24.	336.			13.	121.64		1400.	70900.	322.	52861.			-1078.	-76.98
24.0		11.	414.	19.	355.			8.	70.45		1400.	72300.	747.	53608.			-652.	-46.61
26.0		14.	428.	22.	376.			8.	55.50		1900.	74200.	806.	54414.			-1094.	-57.59
28.0		17.	445.	26.	403.			9.	55.00		2400.	76600.	1514.	55928.			-885.	-36.90
30.0		17.	462.	29.	432.			12.	72.06		2400.	79000.	2980.	58908.			580.	24.16
32.0		15.	477.	24.	456.			9.	60.00		1600.	80600.	1522.	60430.			-78.	-4.90
34.0		14.	491.	19.	475.			5.	34.21		1600.	82200.	1073.	61503.			-527.	-32.95
36.0		14.	505.	19	494.			5.	34.07		1800.	84000.	1198.	62700.			-602.	-33.46
38.0		13.	518.	19	512.			6.	44.23		2000.	86000.	1430.	64130.			-570.	-28.50
40.0	.970	13	531.			15.	527.	2.	14.14	.950	2000.	88000.			1550.	65680.	-450.	-22.52
45.0	.962	31.	562.			37.	564.	6.	20.19	.940	5000.	93000.			3770.	69450.	-1230.	-24.60
50.0	.953	29.	591.			36.	601.	7.	24.56	.930	5000.	98000.			3668.	73118.	-1332.	-26.64
55.0	.944	32.	623.			41.	642.	9.	29.05	.920	5000.	103000.			3568.	76686.	-1432.	-28.65
60.0	.936	23.	646.			31.	673.	8.	33.65	.910	4750.	107750.			3296.	79982.	-1454.	-30.61
65.0	.928	49.	695.			68.	740.	19.	38.38	.900	8250.	116000.			5566.	85548.	-2684.	-32.53
70.0	.919	46.	741.			66.	806.	20.	43.22	.890	10750.	126750.			7050.	92598.	-3700.	-34.42
75.0	.911	50.	791.			74.	880.	24.	48.18	.880	6250.	133000.			3983.	96581.	-2267.	-36.27
80.0	.902	78.	869.			120.	1000.	42.	53.26	.870	9750.	142750.			6038.	102619.	-3712.	-38.08
85.0	.894	87.	956.			138.	1138.	51.	58.47	.860	10250.	153000.			6166.	108785.	-4084.	-39.85
90.0	.885	109.	1065.			179.	1316.	70.	63.60	.850	9500.	162500.			5550.	114334.	-3950.	-41.58
95.0	.877	140.	1205.			237.	1553.	97.	69.26	.840	10000.	172500.			5672.	120006.	-4328.	-43.28
100.0	.868	195.	1400.			341.	1894.	146.	74.84	.830	10500.	183000.			5781.	125787.	-4719.	-44.94

SUMMARY

	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	518.0	86000.	882.0	97000.	1400.0	183000.
ACTUAL/FORECASTED	512.3	64130.	1381.9	61657.	1894.2	125787.
VARIANCE	-5.7	-21870.	499.9	-35343.	494.2	-57213.
% VARIANCE	-1.1	-25.	5.7	-36.	35.3	-31.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 20 SMOOTHING CONSTANTS: TIME= .563 COST= .772 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64.	43.	43.			-21.	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128	41.	83.			-23.	-36.25		12400.	24800.	7629.	15599.			-4771.	-38.48
6.0		48.	176.	40.	123.			-8.	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34.	210.	33.	156.			-1.	-1.65		7200.	41800.	6253.	29251.			-947.	-13.15
10.0		33.	243.	33.	189.			-0.	-.82		7200.	49000.	6118.	35370.			-1082.	-15.02
12.0		28.	271.	26.	215.			-2.	-7.75		4400.	53400.	4830.	40200.			430.	9.78
14.0		27.	298.	25.	240.			-2.	-5.74		4400.	57800.	3854.	46054.			1454.	33.04
16.0		30.	328.	21.	261.			-9.	-31.50		4100.	61900.	1801.	47855.			-2299.	-56.07
18.0		32.	360.	24.	285			-8.	-26.50		3800.	65700.	2253.	50108.			-1547.	-40.72
20.0		32.	392.	27.	311.			-5.	-15.69		3800.	69500.	2431.	52538.			-1369.	-36.03
22.0		11.	403.	24.	336.			13.	121.64		1400.	70900.	322.	52861.			-1078.	-76.98
24.0		11.	414.	19	355.			8.	70.45		1400.	72300.	747.	53608.			-652.	-46.61
26.0		14.	428.	22.	376.			8.	55.50		1900.	74200.	806.	54414.			-1094.	-57.59
28.0		17.	445.	26.	403.			9.	55.00		2400.	76600.	1514.	55928.			-885.	-36.90
30.0		17.	462.	29.	432.			12.	72.06		2400.	79000.	2980.	58908.			580.	24.16
32.0		15.	477.	24.	456.			9.	60.00		1600.	80600.	1522.	60430.			-78.	-4.90
34.0		14.	491.	19.	475.			5.	34.21		1600.	82200.	1073.	61503.			-527.	-32.95
36.0		14.	505.	19.	494.			5.	34.07		1800.	84000.	1198.	62700.			-602.	-33.46
38.0		13.	518.	19.	512.			6.	44.23		2000.	86000.	1430.	64130.			-570.	-28.50
40.0		12.	530.	39.	551.			27.	224.17		2000.	88000.	6687.	70817.			4687.	234.33
45.0	.970	31.	561.			38.	590.	7.	23.90	.950	5000.	93000.			4255.	75072.	-745.	-14.91
50.0	.962	29	590			38.	627.	9	29.51	.940	5000.	98000.			4234.	79305.	-766.	-15.33
55.0	.953	32.	622.			43.	670.	11.	35.30	.930	5000.	103000.			4210.	83515.	-790.	-15.81
60.0	.944	23.	645.			32.	703.	9.	41.30	.920	4750.	107750.			3974.	87489.	-776.	-16.34
65.0	.936	49.	694.			72.	775.	23.	47.51	.910	8250.	116000.			6854.	94342.	-1396.	-16.93
70.0	.928	46.	740.			71.	846.	25.	53.93	.900	10750.	126750.			8862.	103205.	-1888.	-17.56
75.0	.919	50.	790.			80.	926.	30.	60.56	.890	6250.	133000.			5110.	108314.	-1140.	-18.25
80.0	.911	78.	868.			131.	1057.	53.	67.41	.880	9750.	142750.			7900.	116214.	-1850.	-18.98
85.0	.902	87.	955.			152.	1209.	65.	74.49	.870	10250.	153000.			8226.	124440.	-2024.	-19.75
90.0	.894	109.	1064.			198.	1407.	89.	81.79	.860	9500.	162500.			7547.	131987.	-1953.	-20.56
95.0	.885	140.	1204.			265.	1672.	125.	89.34	.850	10000.	172500.			7859.	139846.	-2141.	-21.41
100.0	.877	195.	1399.			384.	2056.	189.	97.12	.840	10500.	183000.			8159.	148004.	-2341.	-22.30

SUMMARY	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	530.0	88000.	869.0	95000.	1399.0	183000.
ACTUAL/FORECASTED	551.2	70817.	1505.1	77187.	2056.3	148004.
VARIANCE	21.2	-17183.	636.1	-17813.	657.3	-34996.
% VARIANCE	4.0	-20.	7.3	-19.	47.0	-19.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 21 SMOOTHING CONSTANTS: TIME= .041 COST= .131 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
X COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR
2.0%		64.	64.	43.	43.			-21.	-33.39%		12400.	12400.	7970.	7970.			-4430.	-35.73%
4.0%		64.	128	41.	83.			-23.	-36.25%		12400.	24800.	7629.	15599.			-4771.	-38.48%
6.0%		48.	176.	40.	123.			-8.	-17.56%		9800.	34600.	7399.	22998.			-2400.	-24.49%
8.0%		34.	210.	33.	156.			-1.	-1.65%		7200.	41800.	6253.	29251.			-947.	-13.15%
10.0%		33.	243.	33.	189.			-0.	-.82%		7200.	49000.	6118.	35370.			-1082.	-15.02%
12.0%		28.	271.	26.	215.			-2.	-7.75%		4400.	53400.	4830.	40200.			430.	9.78%
14.0%		27.	298.	25	240.			-2.	-5.74%		4400.	57800.	5854.	46054.			1454.	33.04%
16.0%		30.	328.	21.	261.			-9.	-31.50%		4100.	61900.	1801.	47855.			-2299.	-56.07%
18.0%		32.	360	24.	285.			-8.	-26.50%		3800.	65700.	2253.	50108.			-1547.	-40.72%
20.0%		32.	392.	27.	311.			-5.	-15.69%		3800.	69500.	2431.	52538.			-1369.	-36.03%
22.0%		11.	403.	24.	336.			13.	121.64%		1400.	70900.	322.	52861.			-1078.	-76.98%
24.0%		11.	414.	19.	355.			8.	70.45%		1400.	72300.	747.	53608.			-652.	-46.61%
26.0%		14.	428.	22.	376.			8.	55.50%		1900.	74200.	806.	54414.			-1094.	-57.59%
28 0%		17.	445.	26.	403.			9.	55.00%		2400.	76600.	1514.	55928.			-885.	-36.90%
30.0%		17.	462.	29	432.			12.	72.06%		2400.	79000.	2980.	58908.			580.	24.16%
32.0%		15.	477	24.	456.			9.	60.00%		1600.	80600.	1522.	60430.			-78.	-4.90%
34.0%		14.	491	19.	475.			5.	34.21%		1600.	82200.	1073.	61503.			-527.	-32.95%
36.0%		14.	505.	19.	494.			5.	34.07%		1800.	84000.	1198.	62700.			-602.	-33.46%
38.0%		13.	518.	19.	512.			6.	44.23%		2000.	86000.	1430.	64130.			-570.	-28.50%
40.0%		12.	530	39.	551.			27.	224.17%		2000.	88000.	6687.	70817.			4687.	234.33%
42.0%		13.	543.	21.	573.			8.	64.46%		2000.	90000.	1188.	72005.			-812.	-40.62%
45.0%	.970	19.	562.			24.	596.	5.	24.95%	.950	3000.	93000.			2833.	74837.	-167.	-5.58%
50.0%	.962	29.	591.			39.	635.	10.	34.52%	.940	5000.	98000.			4791.	79628.	-209.	-4.18%
55.0%	.953	32.	623.			45.	681.	13.	41.69%	.930	5000.	103000.			4856.	84484.	-144.	-2.88%
60.0%	.944	23.	646.			34.	715.	11.	49.19%	.920	4750.	107750.			4671.	89156.	-79.	-1.66%
65.0%	.936	49.	695.			77.	792.	28.	57.00%	.910	8250.	116000.			8207.	97363.	-43.	-.52%
70.0%	.928	46.	741.			76.	868.	30.	65.14%	.900	10750.	126750.			10806.	108169.	56.	.52%
75.0%	.919	50.	791.			87.	955.	37.	73.63%	.890	6250.	133000.			6343.	114512.	93.	1.48%
80.0%	.911	78.	869.			142.	1097.	64.	82.47%	.880	9750.	142750.			9980.	124492.	230.	2.36%
85.0%	.902	87.	956.			167.	1264.	80.	91.67%	.870	10250.	153000.			10572.	135064.	322.	3.14%
90.0%	.894	109.	1065.			219.	1483.	110.	101.25%	.860	9500.	162500.			9865.	144929.	365.	3.84%
95.0%	.885	140.	1205.			296.	1779.	156.	111.22%	.850	10000.	172500.			10445.	155374.	445.	4.45%
100.0%	.877	195.	1400.			432.	2211.	237.	121.58%	.840	10500.	183000.			11023.	166396.	523.	4.98%

SUMMARY	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	543.0	90000.	857.0	93000.	1400.0	183000.
ACTUAL/FORECASTED	572.6	72005.	1638.3	94392.	2210.9	166396.
VARIANCE	29.6	-17995.	781.3	1392.	810.9	-16604.
% VARIANCE	5.4	-20.	9.1	1.	57.9	-9.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 22 SMOOTHING CONSTANTS: TIME= .339 COST= .482 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

% COMP	U/T	TIME (DAYS) BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	COMMITMENTS (R000'S) BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0%		64.	64.	43.	43.			-21.	-33.39%		*12400.	12400.	7970.	7970.			-4430.	-35.73%
4.0%		64.	128.	41.	83.			-23.	-36.25%		*12400.	24800.	7629.	15599.			-4771.	-38.48%
6.0%		48.	176.	40.	123.			-8.	-17.56%		9800.	34600.	7399.	22998.			-2400.	-24.49%
8.0%		34.	210.	33.	156.			-1.	-1.65%		7200.	41800.	6253.	29251.			-947.	-13.15%
10.0%		33.	243.	33	189.			-0.	-.82%		7200.	49000.	6118.	35370.			-1082.	-15.02%
12.0%		28.	271.	26.	215.			-2.	-7.75%		4400.	53400.	4830.	40200.			430.	9.78%
14.0%		27.	298.	25.	240.			-2.	-5.74%		4400.	57800.	5854.	46054.			1454.	33.04%
16.0%		30.	328.	21	261.			-9.	-31.50%		4100.	61900.	1801.	47855.			-2299.	-56.07%
18.0%		32.	360.	24	285.			-8.	-26.50%		3800.	65700.	2253	50108.			-1547.	-40.72%
20.0%		32.	392.	27.	311.			-5.	-15.69%		3800.	69500.	2431.	52538.			-1369.	-36.03%
22.0%		11.	403.	24.	336.			13.	121.64%		1400.	70900.	322.	52861.			-1078.	-76.98%
24.0%		11.	414.	19	355.			8.	70.45%		1400.	72300.	747.	53608.			-652.	-46.61%
26.0%		14.	428.	22.	376.			8.	55.50%		1900.	74200.	806.	54414.			-1094.	-57.59%
28.0%		17.	445.	26.	403.			9.	55.00%		2400.	76600.	1514.	55928.			-885.	-36.90%
30.0%		17.	462.	29.	432.			12.	72.06%		2400.	79000.	2980.	58908.			580.	24.16%
32.0%		15.	477.	24.	456.			9.	60.00%		1600.	80600.	1522.	60430.			-78.	-4.90%
34.0%		14.	491.	19.	475.			5.	34.21%		1600.	82200.	1073.	61503.			-527.	-32.95%
36.0%		14.	505.	19	494.			5.	34.07%		1800.	84000.	1198.	62700.			-602.	-33.46%
38.0%		13.	518.	19.	512.			6.	44.23%		2000.	86000.	1430.	64130.			-570.	-28.50%
40.0%		12.	530	39.	551.			27.	224.17%		2000.	88000.	6687.	70817.			4687.	234.33%
42.0%		13.	543.	21.	573.			8.	64.46%		2000.	90000.	1188.	72005.			-812.	-40.62%
44.0%		12.	555.	20.	592.			8.	62.58%		2000.	92000.	972.	72977.			-1028.	-51.39%
45.0%	.970	7.	562.			8.	600.	1.	15.57%	.950	1000.	93000.			987.	73964.	-13.	-1.32%
50.0%	.962	29.	591.			40.	640.	11.	38.36%	.940	5000.	98000.			5050.	79014.	50.	1.00%
55.0%	.953	32.	623.			47.	687.	15.	46.64%	.930	5000.	103000.			5163.	84176.	163.	3.25%
60.0%	.944	23.	646.			36.	723.	13.	55.34%	.920	4750.	107750.			5008.	89185.	258.	5.44%
65.0%	.936	49.	695.			81.	804.	32.	64.46%	.910	8250.	116000.			8873.	98058.	623.	7.55%
70.0%	.928	46.	741.			80.	884.	34.	74.04%	.900	*10750.	126750.			*11781.	109838.	1031.	9.59%
75.0%	.919	50.	791.			92.	976.	42.	84.08%	.890	6250.	133000.			6972.	116810.	722.	11.55%
80.0%	.911	78.	869.			*152.	1127.	74.	94.60%	.880	9750.	142750.			*11059.	127869.	1309.	13.43%
85.0%	.902	87.	956.			*179.	1306.	92.	105.63%	.870	*10250.	153000.			*11811.	139680.	1561.	15.23%
90.0%	.894	*109.	1065.			*237.	1543.	*128.	117.18%	.860	9500.	162500.			*11110.	150790.	1610.	16.95%
95.0%	.885	*140.	1205.			*321.	1864.	*181.	129.27%	.850	*10000.	172500.			*11858.	162648.	1858.	18.58%
100.0%	.877	*195.	1400.			*472.	2336.	*277.	141.91%	.840	*10500.	183000.			*12613.	175261.	2113.	20.12%

SUMMARY

	TO DATE DAYS	TO DATE RANDS (000'S)	TO COMPLETION DAYS	TO COMPLETION RANDS (000'S)	TOTAL PROJECT DAYS	TOTAL PROJECT RANDS (000'S)
BUDGET	555.0	92000.	845.0	91000.	1400.0	183000.
ACTUAL/FORECASTED	592.1	72977.	1743.7	102284.	2335.8	175261.
VARIANCE	37.1	-19023.	898.7	11284.	935.8	-7739.
% VARIANCE	6.7	-21.	10.6	12.	66.8	-4.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 23 SMOOTHING CONSTANTS: TIME= .522 COST= .606 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

% COMP	U/T	TIME (DAYS) BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	COMMITMENTS (R000'S) BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64.	43.	43.			-21.	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128.	41.	83.			-23.	-36.25		12400.	24800.	7629.	15599.			-4771.	-38.48
6.0		48.	176.	40.	123.			-8.	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34.	210.	33.	156.			-1.	-1.65		7200.	41800.	6253.	29251.			-947.	-13.15
10.0		33.	243.	33.	189.			-0.	-.82		7200.	49000.	6118.	35370.			-1082.	-15.02
12.0		28.	271.	26.	215.			-2.	-7.75		4400.	53400.	4830.	40200.			430.	9.78
14.0		27.	298.	25.	240.			-2.	-5.74		4400.	57800.	5854.	46054.			1454.	33.04
16.0		30.	328.	21.	261.			-9.	-31.50		4100.	61900.	1801.	47855.			-2299.	-56.07
18.0		32.	360.	24.	285.			-8.	-26.50		3800.	65700.	2253.	50108.			-1547.	-40.72
20.0		32.	392.	27.	311.			-5.	-15.69		3800.	69500.	2431.	52538.			-1369.	-36.03
22.0		11.	403.	24.	336.			13.	121.64		1400.	70900.	322.	52861.			-1078	-76.98
24.0		11.	414.	19.	355.			8.	70.45		1400.	72300.	747.	53608.			-652.	-46.61
26.0		14.	428.	22.	376.			8.	55.50		1900.	74200.	806.	54414.			-1094.	-57.59
28.0		17.	445.	26.	403.			9.	55.00		2400.	76600.	1514.	55928.			-885.	-36.90
30.0		17.	462.	29	432.			12.	72.06		2400.	79000.	2980.	58908.			580.	24.16
32.0		15.	477.	24	456.			9.	60.00		1600.	80600.	1522.	60430.			-78.	-4.90
34.0		14.	491.	19.	475.			5.	34.21		1600.	82200.	1073.	61503.			-527.	-32.95
36.0		14.	505.	19.	494.			5.	34.07		1800.	84000.	1198.	62700.			-602.	-33.46
38.0		13.	518.	19	512.			6.	44.23		2000.	86000.	1430.	64130.			-570.	-28.50
40.0		12.	530.	39	551.			27.	224.17		2000.	88000.	6687.	70817.			4687.	234.33
42.0		13.	543.	21.	573.			8.	64.46		2000.	90000.	1188.	72005.			-812.	-40.62
44.0		12.	555.	20.	592.			8.	62.58		2000.	92000.	972.	72977.			-1028.	-51.39
46.0		12.	567.	19.	611			7.	58.33		2000.	94000.	897.	73874.			-1103.	-55.15
50.0	.970	24.	591.			33.	644.	9.	35.55	.950	4000.	98000.			4044.	77918.	44.	1.11
55.0	.962	32.	623.			48.	691.	16.	49.18	.940	5000.	103000.			5169.	83088.	169.	3.39
60.0	.953	23	646.			36.	728.	13.	58.61	.930	4750.	107750.			5016.	88104.	266.	5.60
65.0	.944	49.	695.			83.	810.	34.	68.56	.920	8250.	116000.			8888.	96992.	638.	7.74
70.0	.936	46.	741.			82.	893.	36.	79.04	.910	10750.	126750.			11804.	108795.	1054.	9.80
75.0	.928	50.	791.			95.	988.	45.	90.07	.900	6250.	133000.			6987.	115782.	737.	11.79
80.0	.919	78.	869.			157.	1145.	79.	101.68	.890	9750.	142750.			11086.	126868.	1336.	13.70
85.0	.911	87.	956.			186.	1331.	99.	113.89	.880.	10250.	153000.			11842.	138710.	1592.	15.53
90.0	.902	109.	1065.			247.	1578.	138.	126.73	.870	9500.	162500.			11141.	149851.	1641.	17.28
95.0	.894	140.	1205.			336.	1915.	196.	140.22	.860	10000.	172500.			11894.	161745.	1894.	18.94
100.0	.885	195.	1400.			496	2411.	301.	154.40	.850	10500.	183000.			12654.	174398.	2154.	20.51

SUMMARY	TO DATE DAYS	TO DATE RANDS (000'S)	TO COMPLETION DAYS	TO COMPLETION RANDS (000'S)	TOTAL PROJECT DAYS	TOTAL PROJECT RANDS (000'S)
BUDGET	567.0	94000.	833.0	89000.	1400.0	183000.
ACTUAL/FORECASTED	611.1	73874.	1799.7	100524.	2410.8	174398.
VARIANCE	44.1	-20126.	966.7	11524.	1010.8	-8602.
% VARIANCE	7.8	-21.	11.6	13.	72.2	-5.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 24 SMOOTHING CONSTANTS: TIME= .575 COST= .649 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0*		64.	64.	43.	43.			-21.	-33.39*		*12400.	12400.	7970.	7970.			-4430.	-35.73*
4.0*		64.	128	41.	83.			-23.	-36.25*		*12400.	24800.	7629.	15599.			-4771.	-38.48*
6.0*		48.	176.	40.	123.			-8.	-17.56*		* 9800.	34600.	7399.	22998.			-2400.	-24.49*
8.0*		34.	210.	33.	156.			-1.	-1.65*		* 7200.	41800.	6253.	29251.			-947.	-13.15*
10.0*		33.	243.	33.	189.			-0.	-.82*		* 7200.	49000.	6118.	35370.			-1082.	-15.02*
12.0*		28.	271.	26.	215.			-2.	-7.75*		* 4400.	53400.	4830.	40200.			430.	9.78*
14.0*		27.	298.	25	240			-2.	-5.74*		* 4400.	57800.	5854.	46054.			1454.	33.04*
16.0*		30.	328.	21.	261.			-9.	-31.50*		* 4100.	61900.	1801.	47855.			-2299.	-56.07*
18.0*		32.	360.	24.	285.			-8.	-26.50*		* 3800.	65700.	2253.	50108.			-1547.	-40.72*
20.0*		32.	392.	27.	311.			-5.	-15.69*		* 3800.	69500.	2431.	52538.			-1369.	-36.03*
22.0*		11.	403.	24.	336.			13.	121.64*		* 1400.	70900.	322.	52861.			-1078.	-76.98*
24.0*		11.	414.	19.	355.			8.	70.45*		* 1400.	72300.	747.	53608.			-652.	-46.61*
26.0*		14.	428.	22.	376.			8.	55.50*		* 1900.	74200.	806.	54414.			-1094.	-57.59*
28.0*		17.	445.	26.	403.			9.	55.00*		* 2400.	76600.	1514.	55928.			-885.	-36.90*
30.0*		17.	462.	29.	432.			12.	72.06*		* 2400.	79000.	2980.	58908.			580.	24.16*
32.0*		15.	477.	24.	456.			9.	60.00*		* 1600.	80600.	1522.	60430.			-78.	-4.90*
34.0*		14.	491.	19.	475.			5.	34.21*		* 1600.	82200.	1073.	61503.			-527.	-32.95*
36.0*		14.	505.	19.	494.			5.	34.07*		* 1800.	84000.	1198.	62700.			-602.	-33.46*
38.0*		13.	518.	19.	512.			6.	44.23*		* 2000.	86000.	1430.	64130.			-570.	-28.50*
40.0*		12.	530.	39.	551.			27.	224.17*		* 2000.	88000.	6687.	70817.			4687.	234.33*
42.0*		13.	543.	21.	573.			8.	64.46*		* 2000.	90000.	1188.	72005.			-812.	-40.62*
44.0*		12.	555.	20.	592.			8.	62.58*		* 2000.	92000.	972.	72977.			-1028.	-51.39*
46.0*		12.	567.	19.	611.			7.	58.33*		* 2000.	94000.	897.	73874.			-1103.	-55.15*
48.0*		12.	579.	21.	632			9.	72.25*		* 2000.	96000.	993.	74867.			-1007.	-50.33*
50.0*	970	12.	591.			16.	648.	4.	36.96*	.950	* 2000.	98000.			1990.	76857.	-10.	-.52*
55.0*	962	32.	623.			48.	697.	16.	51.17*	.940	* 5000.	103000.			5069.	81926.	69.	1.38*
60.0*	.953	23.	646.			37.	734.	14.	61.20*	.930	* 4750.	107750.			4903.	86829.	153.	3.21*
65.0*	.944	49.	695.			84.	818.	35.	71.80*	.920	* 8250.	116000.			8659.	95487.	409.	4.95*
70.0*	.936	46.	741.			84.	902.	38.	83.91*	.910	*10750.	126750.			*11461.	106948.	711.	6.61*
75.0*	.928	50.	791.			97.	999.	47.	94.84*	.900	* 6250.	133000.			* 6761.	113709.	511.	8.18*
80.0*	919	78.	869.			*162.	1161.	84.	107.34*	.890	* 9750.	142750.			*10692.	124401.	942.	9.66*
85.0*	.911	87.	956.			*192.	1353.	*105.	120.52*	.880	*10250.	153000.			*11383.	135785.	1133.	11.05*
90.0*	.902	*109.	1065.			*256.	1609.	*147.	134.43*	.870	* 9500.	162500.			*10674.	146458.	1174.	12.35*
95.0*	.894	*140.	1205.			*349.	1957.	*209.	149.09*	.860	*10000.	172500.			*11356.	157814.	1356.	13.56*
100.0	.885	*195.	1400			*516.	2473.	*321.	164.54*	.850	*10500.	183000.			*12041.	169855.	1541.	14.68*

SUMMARY

	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	579.0	96000.	821.0	87000.	1400.0	183000.
ACTUAL/FORECASTED	631.8	74867.	1841.3	94988.	2473.1	169855.
VARIANCE	52.8	-21133.	1020.3	7988.	1073.1	-13145.
% VARIANCE	9.1	-22.	12.4	9.	76.7	-7.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 25 SMOOTHING CONSTANTS: TIME= .679 COST= .653 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

% COMP	U/T	TIME (DAYS) BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR	U/C	COMMITMENTS (R000'S) BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR
2.0		64.	64.	43.	43.			-21.	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128.	41.	83.			-23.	-36.25		12400.	24800.	7629.	15599.			-4771.	-38.48
6.0		48.	176.	40.	123.			-8.	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34.	210.	33.	156.			-1.	-1.65		7200.	41800.	6253.	29251.			-947.	-13.15
10.0		33.	243.	33.	189.			-0.	-.82		7200.	49000.	6118.	35370.			-1082.	-15.02
12.0		28.	271.	26.	215.			-2.	-7.75		4400.	53400.	4830.	40200.			430.	9.78
14.0		27.	298.	25.	240.			-2.	-5.74		4400.	57800.	5854.	46054.			1454.	33.04
16.0		30	328	21.	261.			-9.	-31.50		4100.	61900.	1801.	47855.			-2299.	-56.07
18.0		32	360.	24.	285.			-8.	-26.50		3800.	65700.	2253.	50108.			-1547.	-40.72
20.0		32.	392.	27.	311.			-5.	-15.69		3800.	69500.	2431.	52538.			-1369.	-36.03
22.0		11.	403.	24	336.			13.	121.64		1400.	70900.	322.	52861.			-1078.	-76.98
24.0		11.	414.	19.	355.			8.	70.45		1400.	72300.	747.	53608.			-652.	-46.61
26.0		14.	428.	22.	376.			8.	55.50		1900.	74200.	806.	54414.			-1094.	-57.59
28.0		17.	445.	26.	403.			9.	55.00		2400.	76600.	1514.	55928.			-885.	-36.90
30.0		17.	462.	29.	432.			12.	72.06		2400.	79000.	2980.	58908.			580.	24.16
32.0		15.	477.	24.	456.			9.	60.00		1600.	80600.	1522.	60430.			-78.	-4.90
34.0		14.	491.	19.	475.			5.	34.21		1600.	82200.	1073.	61503.			-527.	-32.95
36.0		14.	505.	19.	494.			5.	34.07		1800.	84000.	1198.	62700.			-602.	-33.46
38.0		13.	518.	19.	512.			6.	44.23		2000.	86000.	1430.	64130.			-570.	-28.50
40.0		12.	530.	39.	551.			27.	224.17		2000.	88000.	6687.	70817.			4687.	234.33
42.0		13.	543.	21.	573.			8.	64.46		2000.	90000.	1188.	72005.			-812.	-40.62
44.0		12.	555.	20.	592.			8.	62.58		2000.	92000.	972.	72977.			-1028.	-51.39
46.0		12.	567.	19	611.			7.	58.33		2000.	94000.	897.	73874.			-1103.	-55.15
48.0		12.	579.	21.	632.			9.	72.25		2000.	96000.	993.	74867.			-1007.	-50.33
50.0		11.	590.	16.	648.			5.	46.27		2000.	98000.	1282.	76150.			-718.	-35.89
55.0	.970	32.	622.			49.	696.	17.	51.61	.950	5000.	103000.			4982.	81132.	-18.	-.36
60.0	.962	23.	645.			37.	734.	14.	61.80	.940	4750.	107750.			4801.	85933.	51.	1.08
65.0	.953	49.	694.			85.	818.	36.	72.58	.930	8250.	116000.			8450.	94383.	200.	2.43
70.0	.944	46.	740.			85.	903.	39.	83.99	.920	10750.	126750.			11145.	105528.	395.	3.68
75.0	.936	50.	790.			98.	1001.	48.	96.05	.910	6250.	133000.			6552.	112080.	302.	4.83
80.0	.928	78.	868.			163.	1164.	85.	108.79	.900	9750.	142750.			10324.	122404.	574.	5.89
85.0	.919	87.	955.			193.	1357.	106.	122.25	.890	10250.	153000.			10952.	133356.	702.	6.85
90.0	.911	109.	1064.			258.	1615.	149.	136.46	.880	9500.	162500.			10233.	143589.	733.	7.71
95.0	.902	140.	1204.			352.	1967.	212.	151.45	.870	10000.	172500.			10848.	154437.	848.	8.48
100.0	.894	195.	1399.			521.	2488.	326.	167.26	.860	10500.	183000.			11461.	165898.	961.	9.15

SUMMARY	TO DATE DAYS	TO DATE RANDS (000'S)	TO COMPLETION DAYS	TO COMPLETION RANDS (000'S)	TOTAL PROJECT DAYS	TOTAL PROJECT RANDS (000'S)
BUDGET	590.0	98000.	809.0	85000.	1399.0	183000.
ACTUAL/FORECASTED	647.9	76150.	1840.1	89748.	2488.0	165898.
VARIANCE	57.9	-21850.	1031.1	4748.	1089.0	-17102.
% VARIANCE	9.8	-22.	12.7	6.	77.8	-9.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 26 SMOOTHING CONSTANTS: TIME= .767 COST= .608 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR
2.0		64.	64.	43.	43.			-21.	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128.	41.	83.			-23.	-36.25		12400.	24800.	7629.	15599.			-4771.	-38.48
6.0		48.	176.	40	123.			-8.	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34.	210.	33	156.			-1.	-1.65		7200.	41800.	6253.	29251.			-947.	-13.15
10.0		33.	243.	33.	189.			-0.	-.82		7200.	49000.	6118.	35370.			-1082.	-15.02
12.0		28.	271.	26.	215.			-2.	-7.75		4400.	53400.	4830.	40200.			430.	9.78
14.0		27	298.	25.	240.			-2.	-5.74		4400.	57800.	5854.	46054.			1454.	33.04
16.0		30	328.	21.	261.			-9.	-31.50		4100.	61900.	1801.	47855.			-2299.	-56.07
18.0		32.	360.	24.	285.			-8.	-26.50		3800.	65700.	2253.	50108.			-1547.	-40.72
20.0		32.	392.	27.	311.			-5.	-15.69		3800.	69500.	2431.	52538.			-1369.	-36.03
22.0		11.	403.	24	336.			13.	121.64		1400.	70900.	322.	52861.			-1078.	-76.98
24.0		11	414.	19	355.			8.	70.45		1400.	72300.	747.	53608.			-652.	-46.61
26.0		14	428.	22.	376.			8.	55.50		1900.	74200.	806.	54414.			-1094.	-57.59
28.0		17.	445.	26	403.			9.	55.00		2400.	76600.	1514.	55928.			-885.	-36.90
30.0		17.	462.	29.	432.			12.	72.06		2400.	79000.	2980.	58908.			580.	24.16
32.0		15.	477	24	456.			9.	60.00		1600.	80600.	1522.	60430.			-78.	-4.90
34.0		14.	491.	19	475.			5.	34.21		1600.	82200.	1073.	61503.			-527.	-32.95
36.0		14.	505.	19.	494.			5.	34.07		1800.	84000.	1198.	62700.			-602.	-33.46
38.0		13.	518.	19.	512.			6.	44.23		2000.	86000.	1430.	64130.			-570.	-28.50
40.0		12.	530.	39	551.			27.	224.17		2000.	88000.	6687.	70817.			4687.	234.33
42.0		13.	543	21	573.			8.	64.46		2000.	90000.	1188.	72005.			-812.	-40.62
44.0		12.	555.	20.	592.			8.	62.58		2000.	92000.	972.	72977.			-1028.	-51.39
46.0		12.	567.	19	611.			7.	58.33		2000.	94000.	897.	73874.			-1103.	-55.15
48.0		12.	579.	21	632.			9.	72.25		2000.	96000.	993.	74867.			-1007.	-50.33
50.0		11.	590.	16	648.			5.	46.27		2000.	98000.	1282.	76150.			-718.	-35.89
52.0		13.	603.	14	661.			1.	4.92		2000.	100000.	1437.	77587.			-563.	-28.14
55.0	.970	20.	623.			29.	690.	9.	44.65	.950	3000.	103000.			2944.	80531.	-56.	-1.88
60.0	.962	23.	646.			37.	727.	14.	60.52	.940	4750.	107750.			4714.	85244.	-36.	-.77
65.0	.953	49.	695.			84.	811.	35.	70.92	.930	8250.	116000.			8270.	93514.	20.	.24
70.0	.944	46.	741.			84.	895.	38.	81.89	.920	10750.	126750.			10874.	104388.	124.	1.15
75.0	.936	50.	791.			97.	992.	47.	93.47	.910	6250.	133000.			6372.	110760.	122.	1.96
80.0	.928	78.	869.			160.	1152.	82.	105.68	.900	9750.	142750.			10010.	120770.	260.	2.67
85.0	.919	87.	956.			190.	1342.	103.	118.55	.890	10250.	153000.			10585.	131356.	335.	3.27
90 0	.911	109.	1065.			253.	1595.	144.	132.11	.880	9500.	162500.			9859.	141215.	359.	3.78
95 0	.902	140.	1205.			345.	1940.	205.	146.39	.870	10000.	172500.			10419.	151634.	419.	4.19
100.0	.894	195	1400.			510	2450.	315.	161.42	.860	10500.	183000.			10972.	162606.	472.	4.50

SUMMARY	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	603.0	100000.	797.0	83000.	1400.0	183000.
ACTUAL/FORECASTED	661.5	77587.	1788.3	85019.	2449.8	162606.
VARIANCE	58.5	-22413.	991.3	2019.	1049.8	-20394.
% VARIANCE	9.7	-22.	12.4	2.	75.0	-11.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 27 SMOOTHING CONSTANTS: TIME= .788 COST= .452 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64.	43.	43.			-21.	-33.39%		12400.	12400.	7970.	7970.			-4430.	-35.73%
4.0		64.	128.	41	83.			-23.	-36.25%		12400.	24800.	7629.	15599.			-4771.	-38.48%
6.0		48.	176.	40.	123.			-8.	-17.56%		9800.	34600.	7399.	22998.			-2400.	-24.49%
8.0		34.	210.	33.	156.			-1.	-1.65%		7200.	41800.	6253.	29251.			-947.	-13.15%
10.0		33.	243.	33.	189.			-0.	-.82%		7200.	49000.	6118.	35370.			-1082.	-15.02%
12.0		28.	271.	26.	215.			-2.	-7.75%		4400.	53400.	4830.	40200.			430.	9.78%
14.0		27.	298.	25.	240.			-2.	-5.74%		4400.	57800.	5854.	46054.			1454.	33.04%
16.0		30.	328.	21.	261.			-9.	-31.50%		4100.	61900.	1801.	47855.			-2299.	-56.07%
18.0		32.	360.	24.	285.			-8.	-26.50%		3800.	65700.	2253.	50108.			-1547.	-40.72%
20.0		32.	392.	27.	311.			-5.	-15.69%		3800.	69500.	2431.	52538.			-1369.	-36.03%
22.0		11.	403.	24.	336.			13.	121.64%		1400.	70900.	322.	52861.			-1078.	-76.98%
24.0		11.	414.	19.	355.			8.	70.45%		1400.	72300.	747.	53608.			-652.	-46.61%
26.0		14.	428.	22.	376.			8.	55.50%		1900.	74200.	806.	54414.			-1094.	-57.59%
28.0		17.	445.	26.	403.			9.	55.00%		2400.	76600.	1514.	55928.			-885.	-36.90%
30.0		17.	462.	29.	432.			12.	72.06%		2400.	79000.	2980.	58908.			580.	24.16%
32.0		15.	477.	24.	456.			9.	60.00%		1600.	80600.	1522.	60430.			-78.	-4.90%
34.0		14.	491.	19	475.			5.	34.21%		1600.	82200.	1073.	61503.			-527.	-32.95%
36.0		14.	505.	19	494.			5.	34.07%		1800.	84000.	1198.	62700.			-602.	-33.46%
38.0		13.	518.	19	512.			6.	44.23%		2000.	86000.	1430.	64130.			-570.	-28.50%
40.0		12.	530.	39.	551.			27.	224.17%		2000.	88000.	6687.	70817.			4687.	234.33%
42.0		13.	543.	21.	573.			8.	64.46%		2000.	90000.	1188.	72005.			-812.	-40.62%
44.0		12.	555.	20.	592.			8.	62.58%		2000.	92000.	972.	72977.			-1028.	-51.39%
46.0		12.	567	19	611.			7.	58.33%		2000.	94000.	897.	73874.			-1103.	-55.15%
48.0		12.	579.	21.	632.			9.	72.25%		2000.	96000.	993.	74867.			-1007.	-50.33%
50.0		11.	590.	16.	648.			5.	46.27%		2000.	98000.	1282.	76150.			-718.	-35.89%
52.0		13.	603.	14.	661.			1.	4.92%		2000.	100000.	1437.	77587.			-563.	-28.14%
54.0		13.	616.	13.	675.			0.	3.38%		2000.	102000.	1726.	79313.			-274.	-13.68%
55.0	970	7.	623.			10.	685.	3.	36.59%	.950	1000.	103000.			970.	80284.	-30.	-2.96%
60.0	962	23.	646.			37.	721.	14.	58.77%	.940	4750.	107750.			4651.	84935.	-99.	-2.08%
65.0	953	49.	695.			83.	804.	34.	68.65%	.930	8250.	116000.			8142.	93077.	-108.	-1.31%
70.0	944	46.	741.			82.	886.	36.	79.04%	.920	10750.	126750.			10681.	103758.	-69.	-.64%
75.0	936	50.	791.			95.	981.	45.	89.98%	.910	6250.	133000.			6246.	110003.	-4.	-.07%
80.0	928	78.	869.			157.	1138.	79.	101.47%	.900	9750.	142750.			9788.	119792.	38.	.39%
85.0	919	87.	956.			186.	1324.	99.	113.56%	.890	10250.	153000.			10328.	130120.	78.	.76%
90.0	911	109.	1065.			247.	1571.	138.	126.25%	.880	9500.	162500.			9597.	139717.	97.	1.02%
95.0	902	140.	1205.			335.	1906.	195.	139.57%	.870	10000.	172500.			10119.	149836.	119.	1.19%
100.0	894	195.	1400.			494.	2400.	299.	153.56%	.860	10500.	183000.			10633.	160469.	133.	1.26%

SUMMARY	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	616.0	102000.	784.0	81000.	1400.0	183000.
ACTUAL/FORECASTED	674.9	79313.	1725.5	81156.	2400.4	160469.
VARIANCE	58.9	-22687.	941.5	156.	1000.4	-22531.
% VARIANCE	9.6	-22.	12.0	0.	71.5	-12.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 28 SMOOTHING CONSTANTS: TIME= .650 COST= .172 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR
2.0		64.	64	43.	43			-21.	-33.39%		12400.	12400.	7970.	7970.			-4430.	-35.73%
4.0		64.	128.	41	83.			-23.	-36.25%		12400.	24800.	7629.	15599.			-4771.	-38.48%
6.0		48.	176.	40.	123.			-8.	-17.56%		9800.	34600.	7399.	22998.			-2400.	-24.49%
8.0		34.	210	33	156.			-1.	-1.65%		7200.	41800.	6253.	29251.			-947.	-13.15%
10.0		33.	243.	33.	189.			-0.	-.82%		7200.	49000.	6118.	35370.			-1082.	-15.02%
12.0		28.	271.	26.	215.			-2.	-7.75%		4400.	53400.	4830.	40200.			430.	9.78%
14.0		27.	298.	25.	240.			-2.	-5.74%		4400.	57800.	5854.	46054.			1454.	33.04%
16.0		30.	328.	21.	261.			-9.	-31.50%		4100.	61900.	1801.	47855.			-2299.	-56.07%
18.0		32.	360.	24.	285			-8.	-26.50%		3800.	65700.	2253.	50108.			-1547.	-40.72%
20.0		32.	392.	27.	311.			-5.	-15.69%		3800.	69500.	2431.	52538.			-1369.	-36.03%
22.0		11.	403.	24.	336.			13.	121.64%		1400.	70900.	322.	52861.			-1078.	-76.98%
24.0		11.	414.	19	355.			8.	70.45%		1400.	72300.	747.	53608.			-652.	-46.61%
26.0		14.	428.	22.	376.			8.	55.50%		1900.	74200.	806.	54414.			-1094.	-57.59%
28.0		17.	445.	26.	403			9.	55.00%		2400.	76600.	1514.	55928.			-885.	-36.90%
30.0		17.	462.	29	432.			12.	72.06%		2400.	79000.	2980.	58908.			580.	24.16%
32.0		15.	477	24	456			9.	60.00%		1600.	80600.	1522.	60430.			-78.	-4.90%
34.0		14.	491	19	475.			5.	34.21%		1600.	82200.	1073.	61503.			-527.	-32.95%
36.0		14.	505.	19.	494.			5.	34.07%		1800	84000.	1198.	62700.			-602.	-33.46%
38.0		13.	518.	19	512.			6.	44.23%		2000.	86000.	1430.	64130.			-570.	-28.50%
40.0		12	530.	39	551.			27.	224.17%		2000	88000.	6687.	70817.			4687.	234.33%
42.0		13.	543.	21.	573			8.	64.46%		2000.	90000.	1188.	72005.			-812.	-40.62%
44.0		12.	555.	20.	592.			8.	62.58%		2000.	92000.	972.	72977.			-1028.	-51.39%
46.0		12.	567.	19.	611.			7.	58.33%		2000.	94000.	897.	73874.			-1103.	-55.15%
48.0		12.	579.	21.	632.			9.	72.25%		2000.	96000.	993.	74867.			-1007.	-50.33%
50.0		11.	590	16	648.			5.	46.27%		2000.	98000.	1282.	76150.			-718.	-35.89%
52.0		13.	603.	14.	661.			1.	4.92%		2000.	100000.	1437.	77587.			-563.	-28.14%
54.0		13.	616	13	675			0.	3.38%		2000.	102000.	1726.	79313.			-274.	-13.68%
56.0		11.	627.	13.	688			2.	19.91%		1950.	103950.	2080.	81393.			130.	6.64%
60.0	.970	19.	646.			29.	717.	10.	52.65%	.950	3800.	107750.			3690.	85082.	-110.	-2.90%
65.0	.962	49.	695.			82.	799.	33.	67.09%	.940	8250	116000.			8060.	93143.	-190.	-2.30%
70 0	.953	46.	741.			81.	880.	35.	77.02%	.930	10750	126750.			10557.	103700.	-193.	-1.80%
75.0	.944	50.	791.			94.	974.	44.	87.44%	.920	6250.	133000.			6162.	109862.	-88.	-1.40%
80 0	.936	78.	869.			155.	1129.	77.	98.37%	.910	9750.	142750.			9641.	119503.	-109.	-1.11%
85.0	.928	87.	956.			183.	1311.	96.	109.83%	.900	10250	153000.			10156.	129659.	-94.	-.92%
90 0	.919	109.	1065.			242.	1553.	133.	121.84%	.890	9500.	162500.			9421.	139080.	-79.	-.83%
95.0	.911	140.	1205.			328	1881.	188.	134.42%	.880	10000.	172500.			9917.	148997.	-83.	-.83%
100.0	.902	195.	1400.			483.	2364.	288.	147.58%	.870	10500.	183000.			10402.	159398.	-98.	-.93%

SUMMARY

	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	627.0	103950	773.0	79050	1400.0	183000.
ACTUAL/FORECASTED	688.1	81393.	1676.1	78006.	2364.2	159398.
VARIANCE	61.1	-22557.	903.1	-1044.	964.2	-23602.
% VARIANCE	9.7	-22.	11.7	-1.	68.9	-13.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 29 SMOOTHING CONSTANTS: TIME= .262 COST= .032 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64.	43	43.			-21.	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128	41.	83.			-23.	-36.25		12400.	24800.	7629.	15599.			-4771.	-38.48
6.0		48.	176.	40.	123.			-8.	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34.	210	33	156.			-1.	-1.65		7200.	41800.	6253.	29251.			-947.	-13.15
10.0		33.	243	33.	189.			-0.	-.82		7200.	49000.	6118.	35370.			-1082.	-15.02
12.0		28	271	26.	215.			-2.	-7.75		4400.	53400.	4830.	40200.			430.	9.78
14.0		27.	298.	25.	240.			-2.	-5.74		4400.	57800.	5854.	46054.			1454.	33.04
16.0		30.	328.	21.	261.			-9.	-31.50		4100.	61900.	1801.	47855.			-2299.	-56.07
18.0		32.	360.	24.	285.			-8.	-26.50		3800.	65700.	2253.	50108.			-1547.	-40.72
20.0		32.	392	27	311.			-5.	-15.69		3800.	69500.	2431.	52538.			-1369.	-36.03
22.0		11.	403.	24	336.			13.	121.64		1400.	70900.	322.	52861.			-1078.	-76.98
24.0		11	414.	19.	355.			8.	70.45		1400.	72300.	747.	53608.			-652.	-46.61
26.0		14	428	22.	376			8.	55.50		1900.	74200.	806.	54414.			-1094.	-57.59
28.0		17	445	26	403.			9.	55.00		2400.	76600.	1514.	55928.			-885.	-36.90
30.0		17	462.	29	432.			12.	72.06		2400.	79000.	2980.	58908.			580.	24.16
32.0		15.	477.	24.	456.			9.	60.00		1600.	80600.	1522.	60430.			-78.	-4.90
34.0		14.	491	19	475.			5.	34.21		1600.	82200.	1073.	61503.			-527.	-32.95
36 0		14.	505.	19.	494.			5.	34.07		1800.	84000.	1198.	62700.			-602.	-33.46
38.0		13.	518.	19.	512.			6.	44.23		2000.	86000.	1430.	64130.			-570.	-28.50
40.0		12.	530	39.	551.			27.	224.17		2000.	88000.	6687.	70817.			4687.	234.33
42.0		13.	543.	21	573.			8.	64.46		2000.	90000.	1188.	72005.			-812.	-40.62
44 0		12.	555.	20.	592.			8.	62.58		2000.	92000.	972.	72977.			-1028.	-51.39
46.0		12.	567	19.	611.			7.	58.33		2000.	94000.	897.	73874.			-1103.	-55.15
48.0		12	579	21.	632.			9.	72.25		2000.	96000.	993.	74867.			-1007.	-50.33
50.0		11	590	16.	648.			5.	46.27		2000.	98000.	1282.	76150.			-718.	-35.89
52 0		13	603	14	661.			1.	4.92		2000.	100000.	1437.	77587.			-563.	-28.14
54 0		13.	616.	13.	675.			0.	3.38		2000.	102000.	1726.	79313.			-274.	-13.68
56.0		11.	627	13.	688			2.	19.91		1950.	103950.	2080.	81393.			130.	6.64
58.0		9.	636	14.	702			5.	51.44		1900.	105850	1983.	83376.			83.	4.39
60.0	970	10	646.			14	716.	4.	44.18	950	1900	107750.			1830.	85206.	-70.	-3.67
65 0	962	49	695			81	797.	32.	65.85	940	8250.	116000.			7984.	93190.	-266.	-3.23
70 0	953	46.	741			81.	878.	35.	75.41	930	10750.	126750.			10439.	103629.	-311.	-2.89
75.0	944	50	791.			93.	971.	43.	85.43	920	6250.	133000			6084.	109713.	-166.	-2.66
80.0	936	78.	869.			153.	1124.	75.	95.92	910	9750.	142750.			9503.	119216.	-247.	-2.53
85 0	928	87	956.			180	1304.	93.	106.89	900	10250.	153000.			9994.	129210.	-256.	-2.50
90.0	919	109.	1065			238.	1542.	129	118.37	890	9500.	162500.			9256.	138466.	-244.	-2.57
95.0	911	140	1205.			323	1864.	183.	130.37	880	10000.	172500			9727.	148193.	-273.	-2.73
100.0	902	195.	1400			474.	2338.	279.	142.90	870	10500.	183000.			10187.	158380.	-313.	-2.98

SUMMARY

	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	636. 0	105850.	764. 0	77150.	1400. 0	183000.
ACTUAL/FORECASTED	701 8	83376.	1636. 1	75004.	2337. 9	158380.
VARIANCE	65 8	-22474.	872. 1	-2146.	937. 9	-24620.
% VARIANCE	10. 3	-21.	11. 4	-3.	67. 0	-13.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 30 SMOOTHING CONSTANTS: TIME= .322 COST= .165 D1T=.970 D2T= 00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)							
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR
2.0*		64.	64.	43.	43.			*-21.	-33.39*		*12400.	12400.	7970.	7970.			-4430.	-35.73*
4.0*		64	128	41	83			*-23.	-36.25*		*12400.	24800.	7629.	15599.			-4771.	-38.48*
6.0*		48.	176	40.	123			-8.	-17.56*		9800.	34600.	7399.	22998.			-2400.	-24.49*
8.0*		34.	210.	33.	156			-1.	-1.65*		7200.	41800.	6253.	29251.			-947.	-13.15*
10.0*		33.	243.	33	189.			-0.	-.82*		7200.	49000.	6118.	35370.			-1082.	-15.02*
12.0*		28.	271	26	215.			-2.	-7.75*		4400.	53400.	4830	40200.			430.	9.78*
14.0*		27	298	25	240			-2.	-5.74*		4400.	57800.	5854.	46054.			1454.	33.04*
16.0*		30.	328.	21.	261.			-9.	-31.50*		4100.	61900.	1801.	47855.			-2299.	-56.07*
18.0*		32.	360.	24	285			-8.	-26.50*		3800.	65700.	2253.	50108.			-1547.	-40.72*
20.0*		32.	392	27	311.			-5.	-15.69*		3800.	69500.	2431.	52538.			-1369.	-36.03*
22.0*		11.	403.	24	336			13.	121.64*		1400.	70900.	322.	52861.			-1078.	-76.98*
24.0*		11.	414.	19	355.			8.	70.45*		1400.	72300.	747.	53608.			-652.	-46.61*
26.0*		14.	428.	22	376.			8.	55.50*		1900.	74200.	806.	54414.			-1094.	-57.59*
28.0*		17.	445.	26	403			9.	55.00*		2400.	76600.	1514.	55928.			-885.	-36.90*
30.0*		17.	462	29.	432.			12.	72.06*		2400.	79000.	2980.	58908.			580.	24.16*
32.0*		15.	477	24.	456			9.	60.00*		1600.	80600.	1522.	60430.			-78.	-4.90*
34.0*		14.	491.	19	475.			5.	34.21*		1600.	82200.	1073.	61503.			-527.	-32.95*
36.0*		14.	505.	19	494			5.	34.07*		1800	84000.	1198.	62700.			-602.	-33.46*
38.0*		13.	518	19.	512			6.	44.23*		2000.	86000.	1430.	64130.			-570.	-28.50*
40.0*		12.	530.	39	551.			27.	224.17*		2000.	88000.	6687.	70817.			4687.	234.33*
42.0*		13.	543	21.	573			8.	64.46*		2000.	90000.	1188.	72005.			-812.	-40.62*
44.0*		12.	555.	20	592.			8.	62.58*		2000.	92000.	972.	72977.			-1028.	-51.39*
46.0*		12.	567	19	611.			7.	58.33*		2000.	94000.	897.	73874.			-1103.	-55.15*
48.0*		12.	579	21.	632			9.	72.25*		2000	96000.	993.	74867.			-1007.	-50.33*
50.0*		11.	590.	16.	648.			5.	46.27*		2000.	98000.	1282.	76150.			-718.	-35.89*
52.0*		13.	603	14	661.			1.	4.92*		2000.	100000.	1437.	77587.			-563.	-28.14*
54.0*		13.	616	13.	675.			0	3.38*		2000.	102000.	1726.	79313.			-274.	-13.68*
56.0*		11.	627.	13	688.			2.	19.91*		1950.	103950.	2080.	81393.			130.	6.64*
58.0*		9.	636	14	702.			5.	51.44*		1900.	105850	1983.	83376.			83.	4.39*
60.0*		9	645	18	720			9.	103.33*		1900.	107750	1119.	84495.			-781.	-41.11*
65.0*	970	49	694			81.	801.	32.	65.62*	.950	8250.	116000.			7905.	92400.	-345.	-4.18*
70.0*	962	46.	740			81.	882.	35.	75.11*	940	*10750.	126750.			*10316.	102715.	-434.	-4.04*
75.0*	953	50.	790			93.	974.	43.	85.05*	930	6250.	133000.			6000.	108715.	-250.	-4.00*
80.0*	944	78	868			*152.	1127.	74.	95.44*	.920	9750.	142750.			9354.	118069.	-396.	-4.07*
85.0*	936	87	955.			*179.	1306.	92	106.31*	910	*10250.	153000.			9817.	127886.	-433.	-4.23*
90.0*	.928	*109.	1064			*237	1543.	*128.	117.67*	.900	9500.	162500			9074.	136959.	-426.	-4.49*
95.0*	.919	*140	1204.			*321	1865.	*181.	129.54*	890	*10000	172500.			9516.	146476.	-484.	-4.84*
100.0	.911	*195.	1399			*472.	2337.	*277.	141.93*	.880	*10500	183000.			9946.	156422.	-554.	-5.28*

SUMMARY

	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	645.0	107750.	754.0	75250.	1399.0	183000.
ACTUAL/FORECASTED	720.1	84495.	1616.5	71927.	2336.6	156422.
VARIANCE	75.1	-23255.	862.5	-3323.	937.6	-26578.
% VARIANCE	11.6	-22.	11.4	-4	67.0	-15.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 31 SMOOTHING CONSTANTS: TIME= .167 COST= .454 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64	64	43	43			-21	-33.39		12400	12400	7970	7970			-4430	-35.73
4.0		64	128	41	83			-23	-36.25		12400	24800	7629	15599			-4771	-38.48
6.0		48	176	40	123			-8	-17.56		9800	34600	7399	22998			-2400	-24.49
8.0		34	210	33	156			-1	-1.65		7200	41800	6253	29251			-947	-13.15
10.0		33	243	33	189			-0	-.82		7200	49000	6118	35370			-1082	-15.02
12.0		28	271	26	215			-2	-7.75		4400	53400	4830	40200			430	9.78
14.0		27	298	25	240			-2	-5.74		4400	57800	5854	46054			1454	33.04
16.0		30	328	21	261			-9	-31.50		4100	61900	1801	47855			-2299	-56.07
18.0		32	360	24	285			-8	-26.50		3800	65700	2253	50108			-1547	-40.72
20.0		32	392	27	311			-5	-15.69		3800	69500	2431	52538			-1369	-36.03
22.0		11	403	24	336			13	121.64		1400	70900	322	52861			-1078	-76.98
24.0		11	414	19	355			8	70.45		1400	72300	747	53608			-652	-46.61
26.0		14	428	22	376			8	55.50		1900	74200	806	54414			-1094	-57.59
28.0		17	445	26	403			9	55.00		2400	76600	1514	55928			-885	-36.90
30.0		17	462	29	432			12	72.06		2400	79000	2980	58908			580	24.16
32.0		15	477	24	456			9	60.00		1600	80600	1522	60430			-78	-4.90
34.0		14	491	19	475			5	34.21		1600	82200	1073	61503			-527	-32.95
36.0		14	505	19	494			5	34.07		1800	84000	1198	62700			-602	-33.46
38.0		13	518	19	512			6	44.23		2000	86000	1430	64130			-570	-28.50
40.0		12	530	39	551			27	224.17		2000	88000	6687	70817			4687	234.33
42.0		13	543	21	573			8	64.46		2000	90000	1188	72005			-812	-40.62
44.0		12	555	20	592			8	62.58		2000	92000	972	72977			-1028	-51.39
46.0		12	567	19	611			7	58.33		2000	94000	897	73874			-1103	-55.15
48.0		12	579	21	632			9	72.25		2000	96000	993	74867			-1007	-50.33
50.0		11	590	16	648			5	46.27		2000	98000	1282	76150			-718	-35.89
52.0		13	603	14	661			1	4.92		2000	100000	1437	77587			-563	-28.14
54.0		13	616	13	675			0	3.38		2000	102000	1726	79313			-274	-13.68
56.0		11	627	13	688			2	19.91		1950	103950	2080	81393			130	6.64
58.0		9	636	14	702			5	51.44		1900	105850	1983	83376			83	4.39
60.0		9	645	18	720			9	103.33		1900	107750	1119	84495			-781	-41.11
62.0		20	665	18	738			-2	-11.55		3300	111050	1135	85630			-2165	-65.60
65.0	970	30	695			49	786	19	61.76	950	4950	116000			4648	70278	-302	-6.09
70.0	962	46	741			80	866	34	74.35	940	10750	126750			10069	100347	-681	-6.34
75.0	953	50	791			92	959	42	84.06	930	6250	133000			5832	106180	-418	-6.68
80.0	944	78	869			151	1110	73	94.21	920	9750	142750			9055	115235	-695	-7.12
85.0	936	87	956			178	1288	91	104.82	910	10250	153000			9465	124700	-785	-7.66
90.0	928	109	1065			235	1524	126	115.89	900	9500	162500			8712	133412	-788	-8.29
95.0	919	140	1205			318	1842	178	127.44	890	10000	172500			9099	142512	-901	-9.01
100.0	911	195	1400			467	2309	272	139.49	880	10500	183000			9470	151982	-1030	-9.81

SUMMARY

	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	665.0	111050	735.0	71950.	1400.0	183000.
ACTUAL/FORECASTED	737.7	85630	1571.2	66352.	2308.9	151982.
VARIANCE	72.7	-25420.	836.2	-5598.	908.9	-31018.
% VARIANCE	10.9	-23	11.4	-8.	64.9	-17.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 32 SMOOTHING CONSTANTS: TIME= .392 COST= .564 D1T= 970 D2T= 00170 D1C=.950 D2C=.00200 G=.30

TIME (DAYS)										COMMITMENTS (R000'S)									
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64	64	43	43			-21	-33.39		12400	12400	7970	7970			-4430	-35.73
4.0		64	128	41	83			-23	-36.25		12400	24800	7629	15599			-4771	-38.48
6.0		48	176	40	123			-8	-17.56		9800	34600	7399	22998			-2400	-24.49
8.0		34	210	33	156			-1	-1.65		7200	41800	6253	29251			-947	-13.15
10.0		33	243	33	189			-0	-.82		7200	49000	6118	35370			-1082	-15.02
12.0		28	271	26	215			-2	-7.75		4400	53400	4830	40200			430	9.78
14.0		27	298	25	240			-2	-5.74		4400	57800	5854	46054			1454	33.04
16.0		30	328	21	261			-9	-31.50		4100	61900	1801	47855			-2299	-56.07
18.0		32	360	24	285			-8	-26.50		3800	65700	2253	50108			-1547	-40.72
20.0		32	392	27	311			-5	-15.69		3800	69500	2431	52538			-1369	-36.03
22.0		11	403	24	336			13	121.64		1400	70900	322	52861			-1078	-76.98
24.0		11	414	19	355			8	70.45		1400	72300	747	53608			-652	-46.61
26.0		14	428	22	376			8	55.50		1900	74200	806	54414			-1094	-57.59
28.0		17	445	26	403			9	55.00		2400	76600	1514	55928			-885	-36.90
30.0		17	462	29	432			12	72.06		2400	79000	2980	58908			580	24.16
32.0		15	477	24	456			9	60.00		1600	80600	1522	60430			-78	-4.90
34.0		14	491	19	475			5	34.21		1600	82200	1073	61503			-527	-32.95
36.0		14	505	19	494			5	34.07		1800	84000	1198	62700			-602	-33.46
38.0		13	518	19	512			6	44.23		2000	86000	1430	64130			-570	-28.50
40.0		12	530	39	551			27	224.17		2000	88000	6687	70817			4687	234.33
42.0		13	543	21	573			8	64.46		2000	90000	1188	72005			-812	-40.62
44.0		12	555	20	592			8	62.58		2000	92000	972	72977			-1028	-51.39
46.0		12	567	19	611			7	58.33		2000	94000	897	73874			-1103	-55.15
48.0		12	579	21	632			9	72.25		2000	96000	993	74867			-1007	-50.33
50.0		11	590	16	648			5	46.27		2000	98000	1282	76150			-718	-35.89
52.0		13	603	14	661			1	4.92		2000	100000	1437	77587			-563	-28.14
54.0		13	616	13	675			0	3.38		2000	102000	1726	79313			-274	-13.68
56.0		11	627	13	688			2	19.91		1950	103950	2080	81393			130	6.64
58.0		9	636	14	702			5	51.44		1900	105850	1983	83376			83	4.39
60.0		9	645	18	720			9	103.33		1900	107750	1119	84495			-781	-41.11
62.0		20	665	18	738			-2	-11.55		3300	111050	1135	85630			-2165	-65.60
64.0		20	685	19	757			-1	-3.10		3300	114350	1159	86789			-2141	-64.87
65.0	970	10	695			16	773	6	60.67	950	1650	116000			1509	88298	-141	-8.57
70.0	962	46	741			80	853	34	72.83	940	10750	126750			9751	98049	-999	-9.30
75.0	953	50	791			91	944	41	82.11	930	6250	133000			5617	103666	-633	-10.12
80.0	944	78	869			150	1093	72	91.78	920	9750	142750			8674	112340	-1076	-11.04
85.0	936	87	956			176	1269	89	101.85	910	10250	153000			9016	121356	-1234	-12.04
90.0	929	109	1065			231	1500	122	112.35	900	9500	162500			8253	129610	-1247	-13.12
95.0	919	140	1205			313	1813	173	123.27	890	10000	172500			8572	138182	-1428	-14.28
100.0	911	195	1400			458	2271	263	134.64	880	10500	183000			8872	147054	-1628	-15.51

SUMMARY	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	685 0	114350.	715. 0	68650.	1400 0	183000.
ACTUAL/FORECASTED	757 1	86789.	1513 4	60264.	2270 6	147054.
VARIANCE	72 1	-27561.	798 4	-8386.	870. 6	-35946.
% VARIANCE	10 5	-24.	11. 2	-12.	62. 2	-20.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 33 SMOOTHING CONSTANTS: TIME= .563 COST= .610 D1T= 970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

% COMP	U/T	TIME (W'S) BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	COMMITMENTS (R000'S) BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0*		64.	64	43	43			-21	-33.39*		*12400	12400	7970.	7970.			-4430.	-35.73*
4.0*		64.	128	41	83			-23.	-36.25*		*12400	24800.	7629	15599.			-4771.	-38.48*
6.0*		48.	176	40	123			-8.	-17.56*		* 9800	34600.	7399.	22998.			-2400.	-24.49*
8.0*		34	210.	33	156			-1.	-1.65*		* 7200	41800	6253.	29251.			-947.	-13.15*
10.0*		33	243.	33	189			-0	-.82*		* 7200.	49000.	6118.	35370.			-1082.	-15.02*
12.0*		28	271	26	215			-2	-7.75*		* 4400	53400.	4830.	40200.			430.	9.78*
14.0*		27	298	25	240			-2.	-5.74*		* 4400	57800.	5854.	46054.			1454.	33.04*
16.0*		30	328	21	261			-9.	-31.50*		* 4100	61900	1801.	47855.			-2299.	-56.07*
18.0*		32	360	24	285			-8	-26.50*		* 3800	65700	2253.	50108.			-1547.	-40.72*
20.0*		32	392	27	311.			-5.	-15.69*		* 3800	69500.	2431.	52538.			-1369	-36.03*
22.0*		11	403	24.	336			13	121.64*		* 1400	70900.	322.	52861.			-1078.	-76.98*
24.0*		11.	414	19.	355			8.	70.45*		* 1400	72300.	747.	53608.			-652.	-46.61*
26.0*		14.	428	22	376			8.	55.50*		* 1900	74200	806.	54414.			-1094.	-57.59*
28.0*		17	445.	26	403.			9.	55.00*		* 2400	76600.	1514.	55928.			-885.	-36.90*
30.0*		17	462	27	432			12.	72.06*		* 2400.	79000.	2980.	58908.			580.	24.16*
32.0*		15	477	24	456			9	60.00*		* 1600	80600.	1522.	60430.			-78.	-4.90*
34.0*		14	491	19	475			5.	34.21*		* 1600	82200.	1073.	61503.			-527.	-32.95*
36.0*		14.	505	19.	494			5	34.07*		* 1800	84000.	1198.	62700.			-602.	-33.46*
38.0*		13.	518	19	512			6	44.23*		* 2000	96000	1430.	64130.			-570.	-28.50*
40.0*		12.	530.	39	551			27	224.17*		* 2000	98000	6687.	70817.			4687.	234.33*
42.0*		13.	543	21	573			8.	64.46*		* 2000	90000.	1188	72005.			-812.	-40.62*
44.0*		12.	555	20.	592			8.	62.58*		* 2000	92000.	972.	72977.			-1028.	-51.39*
46.0*		12	567	19	611.			7.	58.33*		* 2000.	94000.	897.	73874.			-1103.	-55.15*
48.0*		12	579	21	632			9	72.25*		* 2000	96000	993.	74867.			-1007.	-50.33*
50.0*		11	590	16.	648			5.	46.27*		* 2000	98000	1282.	76150.			-718.	-35.89*
52.0*		13	603	14	661			1.	4.92*		* 2000.	100000.	1437.	77587.			-563.	-28.14*
54.0*		13	616	13.	675			0	3.38*		* 2000	102000.	1726.	79313.			-274.	-13.68*
56.0*		11	627	13.	688			2.	19.91*		* 1950	103950	2080.	81393.			130.	6.64*
58.0*		9	636	14	702			5	51.44*		* 1900	105850	1983.	83376.			83.	4.39*
60.0*		9	645	18	720			9	103.33*		* 1900	107750.	1119.	84495.			-781.	-41.11*
62.0*		20	665	18	738.			-2.	-11.55*		* 3300	111050.	1135.	85630.			-2165.	-65.60*
64.0*		20	685	19	757			-1.	-3.10*		* 3300	114350.	1159.	86789.			-2141.	-64.87*
66.0*		19	704	15	773			-4	-18.95*		* 3800	118150.	1311.	88100.			-2489.	-65.51*
70.0*	970	37	741			63	835.	26	69.89*	950	* 8600	126750.			7573.	95673.	-1027.	-11.95*
75.0*	962	50	791			90	925.	40	79.37*	940	* 6250	133000.			5421.	101093.	-829.	-13.27*
80.0*	953	78	869			*147	1072.	69	88.26*	.930	* 9750	142750.			8319.	109412.	-1431.	-14.68*
85.0*	944	87	956			*172.	1244.	85	97.48*	.920	*10250	153000.			8595.	118007.	-1655.	-16.15*
90.0*	936	*109	1065			*226.	1469	*117	107.04*	910	* 9500	162500			7819.	125826.	-1681.	-17.69*
95.0*	928	*140	1205			*304.	1773.	*164.	116.95*	900	*10000	172500			8071.	133898.	-1929.	-19.29*
100.0	919	*195	1400			*443	2216	*248	127.22*	890	*10500	183000			8302	142199.	-2198.	-20.94*

SUMMARY

	TO DATE DAYS	TO DATE RANDS (000'S)	TO COMPLETION DAYS	TO COMPLETION RANDS (000'S)	TOTAL PROJECT DAYS	TOTAL PROJECT RANDS (000'S)
BUDGET	704 0	118150	696 0	64850.	1400. 0	183000.
ACTUAL/FORECASTED	772 5	88100.	1443 7	54099.	2216. 2	142199.
VARIANCE	68 5	-30050	747 7	-10751.	816. 2	-40801.
% VARIANCE	9 7	-25.	10 7	-17.	58. 3	-22.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 34 SMOOTHING CONSTANTS: TIME= .638 COST= .645 D1T= 970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

TIME (DAYS)											COMMITMENTS (R000'S)									
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64	64	42	43			-21.	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128	41	83			-23.	-36.25		12400.	24800	7629.	15599.			-4771.	-38.48
6.0		48.	176	40	123			-8.	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34	210	33	156			-1.	-1.65		7200.	41800.	6253.	29251.			-947.	-13.15
10.0		33.	243	33.	189			-0.	-.82		7200.	49000	6118.	35370.			-1082.	-15.02
12.0		28	271	26	215			-2.	-7.75		4400	53400.	4830.	40200.			430.	9.78
14.0		27.	298	25	240			-2.	-5.74		4400	57800.	5854.	46054.			1454.	33.04
16.0		30.	328	21	261			-9.	-31.50		4100.	61900	1801.	47855.			-2299.	-56.07
18.0		32.	360.	24	285			-8.	-26.50		3800.	65700.	2253.	50108.			-1547.	-40.72
20.0		32.	392	27	311			-5.	-15.69		3800	69500.	2431.	52538.			-1369.	-36.03
22.0		11.	403	24	336			13.	121.64		1400.	70900.	322.	52861.			-1078.	-76.98
24.0		11	414	19	355			8.	70.45		1400.	72300.	747.	53608.			-652.	-46.61
26.0		14	428	22	376			8.	55.50		1700.	74200.	806.	54414.			-1094.	-57.59
28.0		17.	445	26	403			9.	55.00		2400	76600	1514.	55928.			-885.	-36.90
30.0		17.	462.	29	432			12.	72.06		2400	79000	2980.	58908.			580.	24.16
32.0		15.	477	24	456			9.	60.00		1600.	80600	1522.	60430.			-78.	-4.90
34.0		14.	491	19	475			5.	34.21		1600.	82200.	1073.	61503.			-527.	-32.95
36.0		14	505	19	494			5.	34.07		1800.	84000	1198.	62700.			-602.	-33.46
38.0		13	518	19	513			6.	44.23		2000.	86000	1430.	64130.			-570.	-28.50
40.0		12	530	39	551.			27.	224.17		2000.	88000.	6687.	70817.			4687.	234.33
42.0		13	543	21.	573			8.	64.46		2000	90000.	1188.	72005.			-812.	-40.62
44.0		12	555	20	592			8.	62.58		2000	92000	972.	72977.			-1028.	-51.39
46.0		12	567	19.	611			7.	58.33		2000.	94000.	897.	73874.			-1103.	-55.15
48.0		12	579	21	632.			9.	72.25		2000	96000.	993.	74867.			-1007.	-50.33
50.0		11	590	16.	648			5	46.27		2000	98000.	1282.	76150.			-718.	-35.89
52.0		13	603	14	661			1.	4.92		2000.	100000.	1437.	77587.			-563.	-28.14
54.0		13	616	13	675			0.	3.38		2000	102000	1726.	79313.			-274.	-13.68
56.0		11.	627	13	688.			2.	19.91		1950	103950.	2080.	81393.			130.	6.64
58.0		9.	636	14	702			5.	51.44		1900	105850.	1983	83376.			83.	4.39
60.0		9	645	18	720			9.	103.33		1900	107750	1119	84495.			-781.	-41.11
62.0		20.	665	18	738			-2.	-11.55		3300	111050.	1135	85630.			-2165.	-65.60
64.0		20.	685	19	757			-1	-3.10		3300.	114350	1559	86789.			-2141.	-64.87
66.0		19	704	15	773			-4.	-18.95		3800	118150.	1311	99100.			-2489.	-65.51
68.0		18	722	14	787			-4.	-19.89		4300.	122450	1348.	89448.			-2952.	-68.64
70.0	970	19	741			31	818	12.	63.00	950	4300.	126750			3668.	93117.	-632.	-14.69
75.0	962	50	791			88.	906.	38.	76.01	940	6250	133000			5218.	98335.	-1032.	-16.51
80.0	953	78	869			143.	1049.	65.	83.95	930	9750.	142750.			7956.	106291.	-1794.	-18.40
85.0	944	87	956			167	1217.	80	92.14	920	10250	153000			8166.	114458.	-2084.	-20.33
90.0	936	109	1065			219	1435.	110.	100.59	910	9500	162500.			7381.	121839.	-2119.	-22.30
95.0	928	140.	1205			293	1728	153.	109.29	900	10000	172500			7569.	129407.	-2431.	-24.31
100.0	919	195	1400			426.	2154	231	118.26	890	10500	183000			7733.	137140.	-2767.	-26.35

SUMMARY	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	722.0	122450	678.0	60550.	1400.0	183000.
ACTUAL/FORECASTED	786.9	89448	1366.9	47692.	2153.8	137140.
VARIANCE	64.9	-33002	688.9	-12858.	753.8	-45860.
% VARIANCE	9.0	-27	10.2	-21.	53.8	-25.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 35 SMOOTHING CONSTANTS: TIME= .378 COST= .314 D1T= 970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64.	43	43			-21.	-33.39		*12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128.	41.	83			-23.	-36.25		*12400	24800.	7629.	15599.			-4771.	-38.48
6.0		48	176.	40.	123			-8	-17.56		* 9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34.	210.	33.	156			-1.	-1.65		* 7200.	41800.	6253.	29251.			-947.	-13.15
10.0		33.	243	33	189			-0.	- .82		* 7200.	49000	6118.	35370.			-1082.	-15.02
12.0		28.	271	26.	215.			-2.	-7.75		* 4400.	53400	4830.	40200.			430.	9.78
14.0		27.	298	25	240.			-2.	-5.74		* 4400	57800.	5854.	46054.			1454.	33.04
16.0		30	328	21	261			-9.	-31.50		* 4100.	61900.	1801.	47855.			-2299.	-56.07
18.0		32.	360	24	285			-8.	-26.50		* 3800	65700.	2253.	50108.			-1547.	-40.72
20.0		32.	392	27	311			-5.	-15.69		* 3800.	69500.	2431.	52538.			-1369.	-36.03
22.0		11.	403.	24	336			13.	121.64		* 1400.	70900.	322.	52861.			-1078.	-76.98
24.0		11	414	19	355			8.	70.45		* 1400.	72300.	747.	53608.			-652.	-46.61
26.0		14	428	22	376			8	55.50		* 1900.	74200.	806.	54414.			-1094.	-57.59
28.0		17	445	26	403.			9	55.00		* 2400	76600.	1514.	55928.			-885.	-36.90
30.0		17.	462	29	432.			12	72.06		* 2400.	79000.	2980.	58908.			580.	24.16
32.0		15.	477	24	456			9.	60.00		* 1600.	80600.	1522.	60430.			-78.	-4.90
34.0		14.	491	19	475			5.	34.21		* 1600	82200.	1073.	61503.			-527.	-32.95
36.0		14.	505	19	494			5.	34.07		* 1800	84000.	1198.	62700.			-602.	-33.46
38.0		13.	518	19	512.			6.	44.23		* 2000.	86000.	1430.	64130.			-570.	-28.50
40.0		12.	530	39	551.			27	224.17		* 2000.	88000.	6687.	70817.			4687.	234.33
42.0		13	542	21	573			8	64.46		* 2000	90000.	1188.	72005.			-812.	-40.62
44.0		12	555	20	592			8.	62.58		* 2000.	92000.	972.	72977.			-1028.	-51.39
46.0		12.	567	19	611.			7.	58.33		* 2000.	94000.	897.	73874.			-1103.	-55.15
48.0		12.	579	21	632.			9.	72.25		* 2000.	96000	993.	74867.			-1007.	-50.33
50.0		11.	590	16	648			5	46.27		* 2000.	98000.	1282.	76150.			-718.	-35.89
52.0		13.	603	14	661.			1.	4.92		* 2000.	100000.	1437.	77587.			-563.	-28.14
54.0		13.	616	13	675.			0.	3.38		* 2000.	102000.	1726.	79313.			-274.	-13.68
56.0		11	627	13	688			2.	19.91		* 1950	103950.	2080.	81393.			130.	6.64
58.0		9	636	14	702.			5.	51.44		* 1900.	105850.	1983.	83376.			83.	4.39
60.0		9	645	18.	720.			9.	103.33		* 1900	107750	1119.	84495.			-781.	-41.11
62.0		20	665	18	738.			-2.	-11.55		* 3300.	111050.	1135	85630.			-2165.	-65.60
64.0		20	685	19	757			-1	-3.10		* 3300.	114350	1159	86789.			-2141.	-64.87
66.0		19	704	15	773			-4.	-18.95		* 3800.	118150.	1311.	88100.			-2489.	-65.51
68.0		18	722	14	787			-4.	-19.89		* 4300.	122450.	1348	89448.			-2952.	-68.64
70.0		18.	740	19	806.			1	8.28		* 4300.	126750.	1823	91271.			-2477.	-57.61
75.0	.970	50.	790			87.	893.	37.	73.67	.950	6250	133000.			5065.	96337.	-1185.	-18.96
80.0	.962	78.	868			141.	1034.	63.	80.81	.940	9750	142750.			7677.	104014.	-2073.	-21.26
85.0	.953	87.	955			164.	1198.	77.	98.14	.930	10250	153000.			7832.	111846.	-2418.	-23.59
90.0	.944	109	1064			213.	1411.	104.	95.66	.920	9500	162500.			7036.	118881.	-2464.	-25.94
95.0	.936	140	1204.			285.	1696	145.	103.36	.910	10000.	172500.			7170.	126051.	-2830.	-28.30
100.0	.928	195.	1399.			412	2108	217.	111.25	.900	10500	183000.			7280.	133332.	-3220.	-30.66

SUMMARY

	TO DATE DAYS	TO DATE RANDS (000'S)	TO COMPLETION DAYS	TO COMPLETION RANDS (000'S)	TOTAL PROJECT DAYS	TOTAL PROJECT RANDS (000'S)
BUDGET	740 0	126750	659. 0	56250.	1399 0	183000.
ACTUAL/FORECASTED	806 4	91271.	1301. 5	42060.	2107. 9	133332.
VARIANCE	66 4	-35479	642 5	-14190.	708. 9	-49668.
% VARIANCE	9 0	-28.	9 7	-25.	50. 7	-27.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 36 SMOOTHING CONSTANTS: TIME= .127 COST= .550 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G= 30

	TIME (DAYS)									COMMITMENTS (R000'S)								
X COMP%	U/T	BUDGET PROG	BUDGET CUM%	ACTUAL PROG	ACTUAL CUM%	FORECAST PROG	FORECAST CUM%	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2 0%		64	64	43	43			-21	-33.39%		12400	12400	7970	7970			-4430	-35.73%
4 0%		64	128	41	83			-23	-36.25%		12400	24800	7629	15599			-4771	-38.48%
6 0%		48	176	40	123			-8	-17.56%		9800	34600	7399	22998			-2400	-24.49%
8 0%		34	210	33	156			-1	-1.65%		7200	41800	6253	29251			-947	-13.15%
10 0%		33	243	33	189			-0	-.82%		7200	49000	6118	35370			-1082	-15.02%
12 0%		28	271	26	215			-2	-7.75%		4400	53400	4830	40200			430	9.78%
14 0%		27	298	25	240			-2	-5.74%		4400	57800	5854	46054			1454	33.04%
16 0%		30	328	21	261			-9	-31.50%		4100	61900	1801	47855			-2299	-56.07%
18 0%		32	360	24	285			-8	-26.50%		3800	65700	2253	50108			-1547	-40.72%
20 0%		32	392	27	311			-5	-15.69%		3800	69500	2431	52538			-1369	-36.03%
22 0%		11	403	24	336			13	121.64%		1400	70900	322	52861			-1078	-76.98%
24 0%		11	414	19	355			8	70.45%		1400	72300	747	53608			-652	-46.61%
26 0%		14	428	22	376			8	55.50%		1700	74200	806	54414			-1094	-57.59%
28 0%		17	445	26	403			9	55.00%		2400	76600	1514	55928			-885	-36.90%
30 0%		17	462	29	432			12	72.06%		2400	79000	2980	58908			580	24.16%
32 0%		15	477	24	456			9	60.00%		1600	80600	1522	60430			-78	-4.90%
34 0%		14	491	19	475			5	34.21%		1600	82200	1073	61503			-527	-32.95%
36 0%		14	505	19	494			5	34.07%		1800	84000	1198	62700			-602	-33.46%
38 0%		13	518	19	512			6	44.23%		2000	86000	1430	64130			-570	-28.50%
40 0%		12	530	39	551			27	224.17%		2000	88000	6687	70817			4687	234.33%
42 0%		13	543	21	573			8	64.46%		2000	90000	1188	72005			-812	-40.62%
44 0%		12	555	20	592			8	62.58%		2000	92000	972	72977			-1028	-51.39%
46 0%		12	567	19	611			7	58.33%		2000	94000	897	73874			-1103	-55.15%
48 0%		12	579	21	632			9	72.25%		2000	96000	993	74867			-1007	-50.33%
50 0%		11	590	16	648			5	46.27%		2000	98000	1282	76150			-718	-35.89%
52 0%		13	603	14	661			1	4.92%		2000	100000	1437	77587			-563	-28.14%
54 0%		13	616	13	675			0	3.38%		2000	102000	1726	79313			-274	-13.68%
56 0%		11	627	13	688			2	19.91%		1950	103950	2080	81393			130	6.64%
58 0%		9	636	14	702			5	51.44%		1900	105850	1983	83376			83	4.39%
60 0%		9	645	18	720			9	103.33%		1900	107750	1119	84495			-781	-41.11%
62 0%		20	665	18	738			-2	-11.55%		3300	111050	1135	85630			-2165	-65.60%
64 0%		20	685	19	757			-1	-3.10%		3300	114350	1159	86789			-2141	-64.87%
66 0%		19	704	15	773			-4	-18.95%		3800	118150	1311	88100			-2489	-65.51%
68 0%		18	722	14	787			-4	-19.89%		4300	122450	1348	89448			-2952	-68.64%
70 0%		18	740	19	806			1	8.28%		4300	126750	1823	91271			-2477	-57.61%
72 0%		21	761	23	830			2	11.00%		2500	129250	2456	93727			-44	-1.77%
75 0%	970	30	791			51	881	21	71.44%	950	3750	133000			3017	96744	-733	-19.55%
80 0%	962	78	869			139	1020	61	77.83%	940	9750	142750			7609	104353	-2141	-21.96%
85 0%	953	87	956			160	1180	73	84.35%	930	10250	153000			7751	112105	-2499	-24.38%
90 0%	944	109	1065			208	1388	99	91.01%	920	9500	162500			6953	119057	-2547	-26.81%
95 0%	936	140	1205			277	1665	137	97.79%	910	10000	172500			7075	126133	-2925	-29.25%
100.0%	928	195	1400			399	2065	204	104.69%	900	10500	183000			7173	133306	-3327	-31.68%

SUMMARY	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	761.0	129250	639.0	53750	1400.0	183000
ACTUAL/FORECASTED	929.7	93727	1234.8	39579	2064.5	133306
VARIANCE	68.7	-35523	595.8	-14171	664.5	-49694
% VARIANCE	9.0	-27	9.3	-26	47.5	-27

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 37 SMOOTHING CONSTANTS: TIME= .175 COST= .750 D1T= .970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64	64	43	43			-21	-33.39		12400	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128	41	83			-23.	-36.25		12400	24800.	7629.	15599.			-4771.	-38.48
6.0		48.	176.	40	123			-8	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34.	210	33	156			-1.	-1.65		7200	41800.	6253.	29251.			-947.	-13.15
10.0		33	243	33	189			-0.	-.82		7200.	49000.	6118.	35370.			-1082.	-15.02
12.0		28.	271.	26	215			-2.	-7.75		4400	53400.	4830.	40200.			430.	9.78
14.0		27	298.	25	240			-2	-5.74		4400	57800.	5854.	46054.			1454.	33.04
16.0		30.	328	21.	261			-9.	-31.50		4100	61900.	1801.	47855.			-2299.	-56.07
18.0		32.	360	24	285.			-8.	-26.50		3800	65700	2253.	50108.			-1547.	-40.72
20.0		32	392	27.	311.			-5.	-15.69		3800.	69500.	2431.	52538.			-1369.	-36.03
22.0		11.	403	24.	336.			13.	121.64		1400.	70900.	322.	52861.			-1078.	-76.98
24.0		11.	414.	19	355.			8.	70.45		1400.	72300.	747.	53608.			-652.	-46.61
26.0		14.	428.	22.	376			8.	55.50		1900.	74200.	806.	54414.			-1094.	-57.59
28.0		17.	445	26.	403			9	55.00		2400.	76600.	1514.	55928.			-885.	-36.90
30.0		17.	462	29.	432.			12.	72.06		2400.	79000.	2980.	58908.			580.	24.16
32.0		15	477	24	456			9.	60.00		1600.	80600.	1522.	60430.			-78.	-4.99
34.0		14.	491	19	475.			5.	34.21		1600	82200.	1073.	61503.			-527.	-32.95
36.0		14	505	19	494			5	34.07		1800.	84000.	1198.	62700.			-602.	-33.46
38.0		13.	518	19	512.			6.	44.23		2000	86000.	1430.	64130.			-570	-28.50
40.0		12	530.	39	551			27	224.17		2000.	88000.	6687.	70817.			4687.	234.33
42.0		13	543.	21.	573.			8	64.46		2000.	90000.	1188.	72005.			-812.	-40.62
44.0		12	555	20	592.			8.	62.58		2000.	92000	972.	72977.			-1028.	-51.39
46.0		12	567	19	611.			7	58.33		2000.	94000.	897.	73874.			-1103.	-55.15
48.0		12	579	21.	632.			9	72.25		2000.	96000.	993.	74867.			-1007.	-50.33
50.0		11.	590	16	648			5.	46.27		2000.	98000.	1282.	76150.			-718.	-35.89
52.0		13.	603	14	661.			1.	4.92		2000	100000.	1437.	77587.			-563.	-28.14
54.0		13	616	13	675.			0	3.38		2000.	102000.	1726.	79313.			-274.	-13.68
56.0		11	627	13	688			2	19.91		1950.	103950.	2080.	81393.			130.	6.64
58.0		9.	636	14	702			5.	51.44		1900.	105850.	1983.	83376.			83.	4.39
60.0		9.	645	18.	720.			9.	103.33		1900	107750.	1119.	84495.			-781.	-41.11
62.0		20.	665	18	738			-2.	-11.55		3300.	111050.	1135.	85630.			-2165.	-65.60
64.0		20	685	19	757.			-1.	-3.10		3300.	114350.	1159.	86789.			-2141.	-64.87
66.0		19	704	15.	773			-4.	-18.95		3800.	118150.	1311.	88100.			-2489.	-65.51
68.0		18.	722.	14	787			-4.	-19.89		4300.	122450.	1348.	89448.			-2952.	-68.64
70.0		18	740	19.	806			1.	8.28		4300.	126750.	1823.	91271.			-2477.	-57.61
72.0		21	761	23.	830			2.	11.00		2500	129250.	2456.	93727.			-44.	-1.77
74.0		20	781	25.	855			5.	25.35		2500.	131750.	3184.	96911.			684.	27.37
75.0	970	10	791			17	872.	7.	69.38	950	1250.	133000.			1026.	97937.	-224.	-17.92
80.0	962	78.	869			137.	1008.	59.	75.09	940	9750	142750.			7795.	105732.	-1955.	-20.05
85.0	953	87	956			157.	1166.	70	80.88	930	10250	153000.			7972.	113704.	-2278.	-22.23
90.0	944	109.	1065			204.	1369.	95.	86.76	920	9500	162500.			7179.	120883.	-2321.	-24.43
95.0	936	140.	1205.			270.	1639.	130.	92.72	910	10000.	172500.			7334.	128217.	-2666.	-26.66
100.0	928	195	1400			388.	2027.	193.	98.74	900	10500	183000.			7465.	135682.	-3035.	-28.91

SUMMARY

	TO DATE DAYS	TO DATE RANDS (000'S)	TO COMPLETION DAYS	TO COMPLETION RANDS (000'S)	TOTAL PROJECT DAYS	TOTAL PROJECT RANDS (000'S)
BUDGET	781.0	131750.	619.0	51250.	1400.0	183000.
ACTUAL/FORECASTED	854.8	96911.	1171.8	38770.	2026.6	135682.
VARIANCE	73.8	-34839.	552.8	-12480.	626.6	-47318.
% VARIANCE	9.5	-26.	8.9	-24.	44.8	-26.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 38 SMOOTHING CONSTANTS: TIME= 191 COST= 075 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)								COMMITMENTS (R000'S)							
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64	64	43	43			-21.	-33.39		12400	12400	7970.	7970.			-4430.	-35.73
4.0		64.	128	41	83			-23.	-36.25		12400	24800.	7629	15599.			-4771.	-38.48
6.0		48	176	40	123			-8	-17.56		9800	34600	7399.	22998.			-2400.	-24.49
8.0		34.	210	33.	156			-1.	-1.65		7200	41800	6253.	29251.			-947.	-13.15
10.0		33.	243	33	189			-0.	-.82		7200	49000	6118.	35370.			-1082.	-15.02
12.0		28.	271	26	215			-2.	-7.75		4400	53400	4830.	40200.			430.	9.78
14.0		27	298	25	240			-2	-5.74		4400	57800	5854.	46054.			1454.	33.04
16.0		30	328	21.	261			-9.	-31.50		4100	61900	1801.	47855.			-2299.	-56.07
18.0		32.	360	24.	285			-8	-26.50		3800	65700	2253.	50108.			-1547.	-40.72
20.0		32.	392	27.	311			-5	-15.69		3800.	69500	2431.	52538.			-1369.	-36.03
22.0		11.	403.	24	336			13.	121.64		1400	70900.	322.	52861.			-1078.	-76.98
24.0		11	414	19	355.			8	70.45		1400	72300	747.	53608.			-652.	-46.61
26.0		14.	428	22.	376			8	55.50		1900	74200	806.	54414.			-1094.	-57.59
28.0		17.	445	26.	403.			9	55.00		2400	76600	1514.	55928.			-885.	-36.90
30.0		17	462	29.	432			12	72.06		2400.	79000	2980.	58908.			580.	24.16
32.0		15	477	24	456			9	60.00		1600	80600	1522.	60430.			-78.	-4.90
34.0		14.	491	19	475			5	34.21		1600	82200	1073.	61503.			-527.	-32.95
36.0		14	505	19.	494.			5.	34.07		1800.	84000	1198.	62700.			-602.	-33.46
38.0		13	518	19.	512			6	44.23		2000	86000	1430.	64130.			-570.	-28.50
40.0		12.	530	39	551.			27	224.17		2000	88000	6687.	70817.			4687.	234.33
42.0		13	543.	21.	573.			8.	64.46		2000	90000	1188.	72005.			-812.	-40.62
44.0		12	555.	20	592.			8	62.58		2000	92000	972.	72977.			-1028.	-51.39
46.0		12.	567.	19	611			7	58.33		2000	94000.	897.	73874.			-1103.	-55.15
48.0		12	579	21	632			9	72.25		2000	96000	993.	74867.			-1007.	-50.33
50.0		11.	590	16.	648.			5	46.27		2000.	98000.	1282.	76150.			-718.	-35.89
52.0		13.	603	14	661			1.	4.92		2000	100000.	1437	77587.			-563.	-28.14
54.0		13.	616	13	675			0	3.38		2000	102000.	1726.	79313.			-274.	-13.68
56.0		11.	627	13	688			2.	19.91		1950.	103950.	2080.	81393.			130.	6.64
58.0		9.	636	14	702			5.	51.44		1900	105850.	1993.	83376.			83.	4.39
60.0		9	645	18	720			9	103.33		1900	107750	1119.	84495.			-781.	-41.11
62.0		20	665	18	738			-2	-11.55		3300	111050.	1135.	85630.			-2165.	-65.60
64.0		20	685.	19.	757			-1.	-3.10		3300	114350	1159.	86789.			-2141.	-64.87
66.0		19.	704	15	773			-4	-18.95		3800	118150	1311.	88100.			-2489.	-65.51
68.0		18.	722	14	787			-4.	-19.89		4300	122450	1348.	89448.			-2952.	-68.64
70.0		18.	740	19	806			1	8.28		4300	126750	1823.	91271.			-2477.	-57.61
72.0		21.	761.	23.	830			2.	11.00		3500	129250.	2456.	93727.			-44.	-1.77
74.0		20	781	25	855.			5.	25.35		3500	131750.	3184	96911.			684.	27.37
76.0		25	806.	18.	873			-7	-27.28		3200	134950.	1920.	98731.			-1380.	-43.13
80.0	970	63.	869			108.	981.	45.	71.15	950	7800	142750			6346.	105078.	-1454.	-18.64
85.0	962	87	956			155	1136.	68.	77.84	940	10250	153000			8141.	113219.	-2109.	-20.58
90.0	953	109	1065			199	1335	90	82.93	930	9500	162500.			7357.	120575.	-2143.	-22.56
95.0	.944	140.	1205			263	1598	123.	88.05	.920	10000	172500.			7541.	128117.	-2459.	-24.59
100.0	.936	195.	1400			377.	1975.	182.	93.19	.910	10500	183000.			7703.	135819.	-2797.	-26.64

SUMMARY	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	806.0	134950	594.0	48050.	1400.0	183000.
ACTUAL/FORECASTED	873.0	98731	1101.9	37088.	1974.9	135819.
VARIANCE	67.0	-36219	507.9	-10962.	574.9	-47181.
% VARIANCE	8.3	-27.	8.6	-23.	41.1	-26

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 39 SMOOTHING CONSTANTS TIME= .104 COST= .218 D1T=.970 D2T= 00170 D1C=.950 D2C=.00200 G=.30

% COMP	U/T	TIME (DAYS) BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR	U/C	COMMITMENTS (R000'S) BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR
2.0*		64.	64	43.	43			-21.	-33.39*		*12400.	12400.	7970.	7970.			-4430.	-35.73*
4.0*		64.	128	41.	83			-23.	-36.25*		*12400	24800.	7629.	15599.			-4771.	-38.48*
6.0*		48.	176	40	123.			-8.	-17.56*		* 9800.	34600.	7399.	22998.			-2400.	-24.49*
8.0*		34.	210.	33.	156.			-1.	-1.65*		* 7200.	41800.	6253.	29251.			-947.	-13.15*
10.0*		33	243	33.	189.			-0	-.82*		* 7200.	49000.	6118.	35370.			-1082.	-15.02*
12.0*		28	271	26.	215.			-2.	-7.75*		* 4400.	53400	4830.	40200.			430.	9.78*
14.0*		27.	298	25.	240			-2.	-5.74*		* 4400.	57800.	5854.	46054.			1454.	33.04*
16.0*		30.	328.	21.	261.			-9.	-31.50*		* 4100.	61900.	1801.	47855.			-2299.	-56.07*
18.0*		32.	360	24.	285			-8	-26.50*		* 3800.	65700.	2253.	50108.			-1547.	-40.72*
20.0*		32.	392	27	311.			-5	-15.69*		* 3800.	69500.	2431.	52538.			-1369.	-36.03*
22.0*		11.	403	24.	336			13	121.64*		* 1400.	70900.	322.	52861.			-1078.	-76.98*
24.0*		11.	414	19.	355.			8	70.45*		* 1400.	72300.	747.	53608.			-652.	-46.61*
26.0*		14	428	22.	376.			8.	55.50*		* 1900.	74200	806.	54414.			-1094.	-57.59*
28.0*		17.	445.	26.	403.			9.	55.00*		* 2400.	76600.	1514.	55928.			-885.	-36.90*
30.0*		17	462	29.	432.			12.	72.06*		* 2400	79000	2980.	58908.			580.	24.16*
32.0*		15.	477	24.	456			9	60.00*		* 1600.	80600	1522.	60430.			-78.	-4.90*
34.0*		14.	491.	19	475			5	34.21*		* 1600	82200.	1073.	61503.			-527.	-32.95*
36.0*		14	505	19	494			5	34.07*		* 1800	84000.	1198.	62700.			-602.	-33.46*
38.0*		13.	518	19	512.			6	44.23*		* 2000	86000	1430.	64130.			-570.	-28.50*
40.0*		12	530.	39.	551.			27	224.17*		* 2000	88000.	6687.	70817.			4687.	234.33*
42.0*		13.	543	21	573			8.	64.46*		* 2000.	90000.	1188.	72005.			-812.	-40.62*
44.0*		12.	555	20	592.			8.	62.58*		* 2000.	92000.	972.	72977.			-1028.	-51.39*
46.0*		12.	567	19	611.			7	58.33*		* 2000	94000.	897.	73874.			-1103.	-55.15*
48.0*		12.	579	21.	632.			9.	72.25*		* 2000.	96000	993.	74867.			-1007.	-50.33*
50.0*		11.	590	16.	648.			5	46.27*		* 2000.	98000.	1282.	76150.			-718.	-35.89*
52.0*		13.	603	14.	661			1	4.92*		* 2000	100000.	1437.	77587.			-563.	-28.14*
54.0*		13.	616	13.	675.			0.	3.38*		* 2000	102000.	1726.	79313.			-274.	-13.68*
56.0*		11.	627	13	688			2	19.91*		* 1950	103950.	2080.	81393.			130.	6.64*
58.0*		9.	636	14.	702.			5	51.44*		* 1900	105850.	1983.	83376.			83.	4.39*
60.0*		9.	645	18	720			9	103.33*		* 1900.	107750	1119	84495.			-781.	-41.11*
62.0*		20	665.	18	738.			-2.	-11.55*		* 3300	111050	1135.	85630.			-2165.	-65.60*
64.0*		20	685	19	757			-1.	-3.10*		* 3300.	114350	1159.	86789.			-2141.	-64.87*
66.0*		19	704.	15	773.			-4.	-18.95*		* 3800	118150.	1311.	88100.			-2489.	-65.51*
68.0*		18.	722.	14.	787.			-4.	-19.89*		* 4300	122450.	1348.	89448.			-2952.	-68.64*
70.0*		18	740	19.	806.			1	8.28*		* 4300	126750	1823.	91271.			-2477.	-57.61*
72.0*		21.	761	23	830.			2	11.00*		* 2500.	129250	2456.	93727.			-44.	-1.77*
74.0*		20.	781	25	855.			5	25.35*		* 2500	131750.	3184.	96911.			684.	27.37*
76.0*		25	806	18.	873.			-7.	-27.28*		* 3200	134950	1820.	98731.			-1380.	-43.13*
78.0*		31.	837	38.	911.			7.	22.26*		* 3900	138850.	2793.	101524.			-1107.	-28.39*
80.0*	970	32	869			53.	964.	21	66.34*	.950	* 3900.	142750.			3213.	104737.	-687.	-17.62*
85.0*	962	87	956.			*152.	1116.	65	74.95*	940	*10250	153000.			8263.	113001.	-1987.	-19.38*
90.0*	953	*109	1065			*195.	1312.	86.	79.30*	.930	* 9500	162500.			7486.	120486.	-2014.	-21.20*
95.0*	944	*140	1205.			*257	1569	*117.	83.64*	.920	*10000	172500.			7693.	128179.	-2307.	-23.07*
100.0	936	*195.	1400			*367	1935	*172.	87.97*	.910	*10500.	183000.			7876.	136055.	-2624.	-24.99*

SUMMARY

	TO DATE DAYS	TO DATE RANDS (000'S)	TO COMPLETION DAYS	TO COMPLETION RANDS (000'S)	TOTAL PROJECT DAYS	TOTAL PROJECT RANDS (000'S)
BUDGET	837 0	138850	563 0	44150.	1400. 0	183000.
ACTUAL/FORECASTED	910 9	101524.	1024 5	34531.	1935. 4	136055.
VARIANCE	73 9	-37326.	461 5	-9619.	535. 4	-46945.
% VARIANCE	8 8	-27.	8. 2	-22.	38. 2	-26.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 40 SMOOTHING CONSTANTS TIME= .109 COST= .433 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
X COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR
2.0%		64	64	43.	43			-21	-33.39%		12400.	12400.	7970.	7970.			-4430.	-35.73%
4.0%		64	128	41	83			-23	-36.25%		12400.	24800.	7629.	15599.			-4771.	-38.48%
6.0%		48.	176	40.	123			-8	-17.56%		9800.	34600.	7399.	22998.			-2400.	-24.49%
8.0%		34	210	33.	156			-1	-1.65%		7200.	41800.	6253.	29251.			-947.	-13.15%
10.0%		33.	243.	33	189			-0	-.82%		7200.	49000.	6118.	35370.			-1082.	-15.02%
12.0%		28.	271.	26	215			-2.	-7.75%		4400.	53400.	4830.	40200.			430.	9.78%
14.0%		27.	298.	25.	240			-2.	-5.74%		4400.	57800.	5854.	46054.			1454.	33.04%
16.0%		30	328	21.	261.			-9.	-31.50%		4100.	61900.	1801.	47855.			-2299.	-56.07%
18.0%		32.	360	24.	285			-8.	-26.50%		3800.	65700.	2253.	50108.			-1547.	-40.72%
20.0%		32.	392	27	311			-5.	-15.69%		3800.	69500.	2431.	52538.			-1369.	-36.03%
22.0%		11.	403	24	336			13.	121.64%		1400.	70900.	322.	52861.			-1078.	-76.98%
24.0%		11.	414	19	355.			8.	70.45%		1400.	72300.	747.	53608.			-652.	-46.61%
26.0%		14	428	22	376.			8.	55 50%		1900.	74200.	806.	54414.			-1094.	-57.59%
28.0%		17	445	26.	403.			9.	55.00%		2400.	76600.	1514.	55928.			-885.	-36.90%
30.0%		17.	462.	29.	432			12.	72.06%		2400.	79000.	2980.	58908.			580.	24.16%
32.0%		15.	477.	24	456.			9	60.00%		1600.	80600.	1522.	60430.			-78.	-4.90%
34.0%		14.	491.	19.	475			5.	34.21%		1600.	82200.	1073.	61503.			-527.	-32.95%
36.0%		14.	505	19	494.			5.	34.07%		1800.	84000.	1198.	62700.			-602.	-33.46%
38.0%		13.	518	19.	512			6.	44 23%		2000.	86000.	1430.	64130.			-570.	-28.50%
40.0%		12.	530.	39	551.			27.	224.17%		2000.	88000.	6687.	70817.			4687.	234.33%
42.0%		13.	543	21	573			8	64.46%		2000.	90000.	1188.	72005.			-812.	-40.62%
44.0%		12.	555	20	592			8	62.58%		2000.	92000.	972.	72977.			-1028.	-51.39%
46.0%		12.	567	19.	611.			7.	58.33%		2000.	94000.	897.	73874.			-1103.	-55.15%
48.0%		12.	579.	21	632			9	72.25%		2000.	96000.	993.	74867.			-1007.	-50.33%
50.0%		11.	590	16.	648.			5.	46.27%		2000.	98000.	1282.	76150.			-718.	-35.89%
52.0%		13.	603	14	661.			1.	4.92%		2000.	100000.	1437.	77587.			-563.	-28.14%
54.0%		13.	616	13.	675.			0.	3.38%		2000	102000.	1726.	79313.			-274.	-13.68%
56.0%		11.	627	13	688			2.	19.91%		1950.	103950.	2080.	81393.			130.	6.64%
58.0%		9	636	14	702.			5.	51.44%		1700.	105850.	1983.	83376.			83.	4.39%
60.0%		9.	645	18.	720.			9	103.33%		1900.	107750.	1119.	84495.			-781.	-41.11%
62.0%		20.	665	18.	738			-2.	-11.55%		3300	111050.	1135.	85630.			-2165.	-65.60%
64.0%		20.	685.	19.	757			-1.	-3.10%		3300.	114350.	1159.	86789.			-2141.	-64.87%
66.0%		19	704	15.	773.			-4.	-18.95%		3800.	118150.	1311.	88100.			-2489.	-65.51%
68.0%		18	722	14	787			-4.	-19.89%		4300.	122450.	1348.	89448.			-2952.	-68.64%
70.0%		18	740	19	806			1.	8.28%		4300.	126750.	1823.	91271.			-2477.	-57.61%
72.0%		21.	761	23	830			2	11.00%		2500.	129250.	2456.	93727.			-44.	-1.77%
74.0%		20	781	25	855			5	25.35%		2500.	131750	3184.	96911.			684.	27.37%
76.0%		25	806	18	873			-7	-27.28%		3200.	134950.	1820.	98731.			-1380.	-43.13%
78.0%		31.	837	38.	911			7.	22.26%		3900.	138850.	2793.	101524.			-1107.	-28.39%
80.0%		31.	868	26.	937			-5.	-16.94%		3900.	142750.	2530.	104054.			-1370.	-35.12%
85.0%	.970	87.	955			150	1087	63.	72.68%	.950	10250.	153000.			8284.	112339	-1966.	-19.18%
90.0%	.962	109	1064			192.	1279	83	76.32%	.940	9500	162500.			7508.	119847.	-1992.	-20.97%
95.0%	.953	140	1204			252	1531.	112.	79.91%	.930	10000.	172500.			7720.	127566.	-2280.	-22.80%
100.0%	.944	195.	1399			358	1889	163.	83.46%	.920	10500	183000.			7908	135474.	-2592.	-24.69%

SUMMARY	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	868.0	142750	531.0	40250	1399.0	183000.
ACTUAL/FORECASTED	936.6	104054	952.0	31420	1888.7	135474.
VARIANCE	68.6	-38696.	421.0	-8830	489.7	-47526.
% VARIANCE	7.9	-27.	7.9	-22.	35.0	-26.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 41 SMOOTHING CONSTANTS TIME= .433 COST= .575 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 C=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64.	43	43			-21	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64	128	41	83			-23	-36.25		12400.	24800.	7629.	15599.			-4771.	-38.48
6.0		48	176	40	123			-8	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34.	210	33	156			-1.	-1.65		7200.	41800.	6253.	29251			-947.	-13.15
10.0		33	243	33	189			-0.	-.82		7200.	49000.	6118.	35370.			-1082.	-15.02
12.0		28	271	26	215			-2.	-7.75		4400.	53400.	4830.	40200.			430.	9.78
14.0		27	298	25	240			-2	-5.74		4400.	57800.	5854.	46054.			1454.	33.04
16.0		30	328	21	261			-9.	-31.50		4100.	61900.	1801.	47855.			-2299.	-56.07
18.0		32	360	24	285			-8.	-26.50		3800.	65700.	2253.	50108.			-1547.	-40.72
20.0		32.	392.	27	311			-5	-15.69		3800.	69500.	2431.	52538.			-1369.	-36.03
22.0		11	403	24	336			13	121.64		1400.	70900	322.	52861.			-1078.	-76.98
24.0		11	414	19	355			8	70.45		1400.	72300.	747.	53608.			-652.	-46.61
26.0		14	428	22	376			8	55.50		1900.	74200.	806.	54414.			-1094.	-57.59
28.0		17	445	26.	403			9	55.00		2400.	76600.	1514.	55928.			-885.	-36.90
30.0		17	462	29	432			12.	72.06		2400.	79000.	2980.	58908.			580.	24.16
32.0		15	477	24	456			9	60.00		1600.	80600.	1522.	60430.			-78.	-4.90
34.0		14	491	19	475			5.	34.21		1600.	82200.	1073.	61503.			-527.	-32.95
36.0		14.	505	19.	494			5.	34.07		1800.	84000.	1198.	62700.			-602.	-33.46
38.0		13	518	19.	512			6.	44.23		2000.	86000.	1430.	64130.			-570.	-28.50
40.0		12	530	39.	551			17	224.17		2000.	88000.	6687.	70817.			4687.	234.33
42.0		13	543	21	573			8.	64.46		2000.	90000.	1188.	72005.			-812.	-40.62
44.0		12	555	20	592			8	62.58		2000.	92000.	972.	72977.			-1028.	-51.39
46.0		12	567	19.	611			7.	58.33		2000.	94000.	897.	73874.			-1103.	-55.15
48.0		12	579.	21	632			9.	72.25		2000.	96000.	993.	74867.			-1007.	-50.33
50.0		11	590	16	648			5.	46.27		2000.	98000.	1282.	76150.			-718.	-35.89
52.0		13	603	14	661.			1.	4.92		2000.	100000.	1437.	77587.			-563.	-28.14
54.0		13.	616	13	675			0.	3.38		2000.	102000.	1726.	79313.			-274.	-13.68
56.0		11.	627	13.	688			2.	19.91		1950.	103950.	2080.	81393.			130.	6.64
58.0		9.	636	14	702.			5	51.44		1900.	105850.	1983.	83376.			83.	4.39
60.0		9.	645	18.	720			9	103.33		1900.	107750.	1119.	84495.			-781.	-41.11
62.0		20	665	18.	738			-2.	11.55		3300.	111050	1135.	85630.			-2165.	-65.60
64.0		20	685	19.	757			-1	-3.10		3300.	114350.	1159.	86789.			-2141.	-64.87
66.0		19	704	15	773			-4.	-18.95		3800.	118150.	1311.	88100.			-2489.	-65.51
68.0		18	722	14	787			-4.	-19.89		4300.	122450.	1348.	89448.			-2952.	-68.64
70.0		18	740	19	806.			1	8.28		4300.	126750.	1823.	91271.			-2477.	-57.61
72.0		21.	761	23	830.			2	11.00		2500.	129250	2456.	93727.			-44.	-1.77
74.0		20	781	25	855			5.	25.35		2500.	131750.	3184.	96911.			684.	27.37
76.0		25.	806	18	873.			-7.	-27.28		3200.	134950	1820.	98731.			-1380.	-43.13
78.0		31	837	38.	911.			7.	22.26		3900.	138850	2793.	101524.			-1107.	-28.39
80.0		31	868.	26	937			-5	-16.94		3900.	142750.	2530.	104054.			-1370.	-35.12
82.0		35	903	22	959			-13.	-36.14		4100.	146850	2181.	106236.			-1919.	-46.80
85.0	.970	53	956			89	1048	36	67.44	.950	6150.	153000			4927.	111163.	-1223.	-19.89
90.0	.962	109	1065			188	1236.	79.	72.81	.940	9500.	162500			7429.	118592.	-2071.	-21.80
95.0	.953	140	1205.			246.	1482.	106.	75.54	.930	10000.	172500			7625.	126217.	-2375.	-23.75
100.0	.944	195	1400.			347.	1829	152	78.20	.920	10500.	183000.			7797.	134014.	-2703.	-25.74

SUMMARY	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	903.0	146850.	497.0	36150.	1400.0	183000
ACTUAL/FORECASTED	959.0	106236.	870.3	27778	1829.3	134014.
VARIANCE	56.0	-40614.	373.3	-8372.	429.3	-48986
% VARIANCE	6.2	-28.	75.	-23.	30.7	-27

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 42 SMOOTHING CONSTANTS: TIME= .514 COST= .603 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

TIME (DAYS)										COMMITMENTS (R000'S)									
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64.	43	43			-21	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64	128.	41	83			-23.	-36.25		12400.	24800.	7629.	15599.			-4771.	-38.48
6.0		48	176.	40	123.			-8.	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34.	210.	33	156.			-1.	-1.65		7200.	41800.	6253.	29251.			-947.	-13.15
10.0		33.	243	33	189.			-0.	-.82		7200.	49000.	6118.	35370.			-1082.	-15.02
12.0		28.	271	26.	215.			-2.	-7.75		4400.	53400.	4830.	40200.			430.	9.78
14.0		27.	298	25	240.			-2.	-5.74		4400.	57800.	5854.	46054.			1454.	33.04
16.0		30.	328	21.	261.			-9.	-31.50		4100.	61900.	1801.	47855.			-2299.	-56.07
18.0		32.	360	24.	285			-8.	-26.50		3800.	65700.	2253.	50108.			-1547.	-40.72
20.0		32.	392	27	311			-5	-15.69		3800.	69500.	2431.	52538.			-1369.	-36.03
22.0		11.	403	24.	336			13	121.64		1400.	70900.	322.	52861.			-1078.	-76.98
24.0		11.	414.	19.	355			8.	70.45		1400.	72300.	747.	53608.			-652.	-46.61
26.0		14	428	22	376			8	55.50		1900.	74200.	806.	54414.			-1094.	-57.59
28.0		17	445	26	403			9.	55.00		2400.	76600.	1514.	55928.			-885.	-36.90
30.0		17.	462.	29.	432.			12.	72.06		2400.	79000.	2980.	58908.			580.	24.16
32.0		15.	477.	24.	456.			9.	60.00		1600.	80600.	1522.	60430.			-78.	-4.90
34.0		14.	491.	19.	475			5.	34.21		1600.	82200.	1073.	61503.			-527.	-32.95
36.0		14.	505	19.	494			5.	34.07		1800.	84000.	1198.	62700.			-602.	-33.46
38.0		13.	518	19	512			6.	44.23		2000.	86000.	1430.	64130.			-570.	-28.50
40.0		12.	530	39	551.			27.	224.17		2000.	88000.	6687.	70817.			4687.	234.33
42.0		13	543	21	573			8	64.46		2000.	90000.	1188.	72005.			-812.	-40.62
44.0		12	555.	20	592			8.	62.58		2000.	92000.	972.	72977.			-1028.	-51.39
46.0		12.	567.	19	611			7.	58.33		2000.	94000.	897.	73874.			-1103.	-55.15
48.0		12.	579	21	632.			9.	72.25		2000.	96000.	993.	74867.			-1007.	-50.33
50.0		11	590	16	648			5.	46.27		2000.	98000.	1282.	76150.			-718.	-35.89
52.0		13.	603.	14	661			1.	4.92		2000.	100000.	1437.	77587.			-563.	-28.14
54.0		13.	616.	13.	675.			0.	3.38		2000.	102000.	1726.	79313.			-274.	-13.68
56.0		11.	627.	13.	688.			2	19.91		1950.	103950.	2080.	81393.			130.	6.64
58.0		9	636	14	702.			5.	51.44		1900.	105850.	1983.	83376.			83.	4.39
60.0		9.	645	18	720.			9.	103.33		1900.	107750.	1119.	84495.			-781.	-41.11
62.0		20.	665.	18	738			-2.	-11.55		3300.	111050.	1135.	85630.			-2165.	-65.60
64.0		20.	685.	19	757			-1.	-3.10		3300.	114350.	1159.	86789.			-2141.	-64.87
66.0		19.	704.	15	773			-4.	-18.95		3800.	118150.	1311.	88100.			-2489.	-65.51
68.0		18.	722	14	787			-4	-19.89		4300.	122450.	1348.	89448.			-2952.	-68.64
70.0		18.	740	19	806.			1.	8.28		4300.	126750.	1823.	91271.			-2477.	-57.61
72.0		21.	761	23	830			2.	11.00		2500.	129250.	2456.	93727.			-44.	-1.77
74.0		20	781.	25.	855			5.	25.35		2500.	131750.	3184.	96911.			684.	27.37
76.0		25	806.	18.	873			-7.	-27.28		3200.	134950.	1820.	98731.			-1380.	-43.13
78.0		31.	837.	38	911.			7	22.26		3900.	138850.	2793.	101524.			-1107.	-28.39
80.0		31.	868.	26	937			-5.	-16.94		3900.	142750.	2530.	104054.			-1370.	-35.12
82.0		35.	903	22	959			-13	-36.14		4100.	146850.	2181.	106236.			-1919.	-46.80
84.0		35	938	25	984			-10	-29.00		4100.	150950.	2452.	108688.			-1648.	-40.18
85.0	970	18.	956.			29.	1013.	11.	61.63	950	2050.	153000.			1624.	110312.	-426.	-20.78
90.0	962	109.	1065			184.	1197.	75.	69.15	940	9500.	162500.			7330.	117643.	-2170.	-22.84
95.0	953	140	1205.			239.	1437.	99.	71.81	930	10000.	172500.			7506.	125149.	-2494.	-24.94
100.0	944	195.	1400			337	1774.	142.	72.77	920	10500.	183000.			7658.	132807.	-2842.	-27.06

SUMMARY	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	938.0	150950.	462.0	32050.	1400.0	183000.
ACTUAL/FORECASTED	983.8	108688	789.8	24119	1773.6	132807.
VARIANCE	45.8	-42262.	327.8	-7931.	373.6	-50193.
% VARIANCE	4.9	-28.	7.1	-25.	26.7	-27.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 43 SMOOTHING CONSTANTS TIME= .332 COST= .217 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE XVAR
2.0		64.	64.	43.	43.			-21.	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128.	41.	83			-23	-36.25		12400.	24800.	7629.	15599.			-4771.	-38.48
6.0		48.	176.	40	123			-8.	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34	210	33	156			-1.	-1.65		7200.	41800.	6253.	29251.			-947.	-13.15
10.0		33	243	33	189			-0	-.82		7200.	49000.	6118.	35370.			-1082.	-15.02
12.0		28	271	26.	215			-2.	-7.75		4400.	53400.	4830.	40200.			430.	9.78
14.0		27	298	25.	240			-2.	-5.74		4400.	57800.	5854.	46054.			1454.	33.04
16.0		30.	328	21.	261			-9.	-31.50		4100.	61900.	1801.	47855.			-2299.	-56.07
18.0		32	360	24	285			-8.	-26.50		3800.	65700.	2253.	50108.			-1547.	-40.72
20.0		32.	392	27	311			-5.	-15.69		3800.	69500.	2431.	52538.			-1369.	-36.03
22.0		11.	403	24	336			13.	121.64		1400.	70900.	322.	52861.			-1078.	-76.98
24.0		11.	414	19.	355.			8.	70.45		1400.	72300.	747.	53608.			-652.	-46.61
26.0		14.	428	22.	376.			8	55.50		1900.	74200.	806.	54414.			-1094.	-57.59
28.0		17.	445	26.	403			9	55.00		2400.	76600.	1514.	55928.			-885.	-36.90
30.0		17.	462.	29	432.			12.	72.06		2400.	79000.	2980.	58908.			580.	24.16
32.0		15.	477	24	456			9	60.00		1600.	80600.	1522.	60430.			-78.	-4.90
34.0		14.	491	19.	475.			5.	34.21		1600.	82200.	1073.	61503.			-527.	-32.95
36.0		14.	505.	19.	494.			5	34.07		1800.	84000.	1198.	62700.			-602.	-33.46
38.0		13	518.	19	512.			6	44.23		2000.	86000.	1430.	64130.			-570.	-28.50
40.0		12.	530	39	551			27.	224.17		2000.	88000.	6687.	70817.			4687.	234.33
42.0		13.	543	21.	573			8	64.46		2000.	90000.	1188.	72005.			-812.	-40.62
44.0		12.	555	20	592			8	62.58		2000.	92000.	972.	72977.			-1028.	-51.39
46.0		12.	567	19	611			7	58.33		2000.	94000.	897.	73874.			-1103.	-55.15
48.0		12	579	21	632			9.	72.25		2000.	96000.	993.	74867.			-1007.	-50.33
50.0		11	590	16	648			5	46.27		2000.	98000.	1282.	76150.			-718.	-35.89
52.0		13	603	14.	661			1	4.92		2000.	100000.	1437.	77587.			-563.	-28.14
54.0		13	616	13	675			0	3.38		2000.	102000.	1726.	79313.			-274.	-13.68
56.0		11.	627	13	688			2	19.91		1950.	103950.	2080.	81393.			130.	6.64
58.0		9.	636.	14	702.			5	51.44		1900.	105850.	1983.	83376.			83.	4.39
60.0		9	645	18	720			9	103.33		1900.	107750.	1119.	84495.			-781.	-41.11
62.0		20	665	18	738.			-2	-11.55		3300.	111050.	1135	85630.			-2165.	-65.60
64.0		20	685	19	757			-1	-3.10		3300.	114350.	1159.	86789.			-2141.	-64.87
66.0		19.	704.	15	773.			-4.	-18.95		3800.	118150.	1311.	88100.			-2489.	-65.51
68.0		18.	722.	14	787			-4.	-19.89		4300.	122450.	1348.	89448.			-2952.	-68.64
70.0		18.	740.	19	806			1.	8.28		4300.	126750.	1823.	91271.			-2477.	-57.61
72.0		21	761	23	830			2.	11.00		2500.	129250.	2456.	93727.			-44.	-1.77
74.0		20.	781	25	855			5	25.35		2500.	131750.	3184.	96911.			684.	27.37
76.0		25.	806	18	873			-7.	-27.28		3200.	134950.	1820.	98731.			-1380.	-43.13
78.0		31.	837.	38	911			7.	22.26		3900.	138850.	2793.	101524.			-1107.	-28.39
80.0		31.	868.	26	937			-5.	-16.94		3900.	142750.	2530.	104054.			-1370.	-35.12
82.0		35	903.	22	959			-13	-36.14		4100.	146850.	2181.	106236.			-1919.	-46.80
84.0		35.	938.	25.	984			-10	-29.00		4100.	150950.	2452.	108688.			-1648.	-40.18
86.0		39	977.	32.	1016			-6.	-16.67		3950.	154900.	3211.	111900.			-739.	-18.70
90.0	970	88	1065.			145	1161	57	64.92	.950	7600.	162500.			5816.	117715.	-1784.	-23.48
95.0	962	140.	1205.			234	1396	94.	67.48	.940	10000.	172500.			7432.	125147.	-2568.	-25.68
100.0	.953	195	1400.			329	1724	133.	68.42	.930	10500.	183000.			7569.	132716.	-2931.	-27.91

SUMMARY

	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	977 0	154900.	423. 0	28100.	1400. 0	183000.
ACTUAL/FORECASTED	1016 3	111900	708. 0	20817.	1724. 4	132716.
VARIANCE	39. 3	-43000	285. 0	-7283.	324. 4	-50284
% VARIANCE	4. 0	-28.	6. 7	-26.	23. 2	-27.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 44 SMOOTHING CONSTANTS: TIME= .353 COST= .074 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)										COMMITMENTS (R000'S)									
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64	43	43			-21	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64	128	41	83			-23.	-36.25		12400.	24800.	7629.	15599.			-4771.	-38.48
6.0		48.	176	40	123			-8.	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34.	210	33	156.			-1.	-1.65		7200.	41800.	6253.	29251.			-947.	-13.15
10.0		33.	243.	33	189			-0.	-.82		7200.	49000.	6118.	35370.			-1082.	-15.02
12.0		28.	271.	26	215.			-2.	-7.75		4400.	53400.	4830.	40200.			430.	9.78
14.0		27.	298	25	240			-2.	-5.74		4400.	57800.	5854.	46054.			1454.	33.04
16.0		30.	328	21	261			-9.	-31.50		4100.	61900.	1801.	47855.			-2299.	-56.07
18.0		32.	360	24.	285.			-8.	-26.50		3800.	65700.	2253.	50108.			-1547.	-40.72
20.0		32.	392	27.	311.			-5.	-15.69		3800.	69500.	2431.	52538.			-1369.	-36.03
22.0		11.	403	24	336			13.	121.64		1400.	70900.	322.	52861.			-1078.	-76.98
24.0		11.	414	19.	355.			8.	70.45		1400.	72300.	747.	53608.			-652.	-46.61
26.0		14.	428	22.	376			8.	55.50		1900.	74200.	806.	54414.			-1094.	-57.59
28.0		17.	445	26	403.			9.	55.00		2400.	76600.	1514.	55928.			-885.	-36.90
30.0		17	462	29	432			12.	72.06		2400.	79000.	2980.	58908.			580.	24.16
32.0		15	477.	24.	456			9.	60.00		1600.	80600.	1522.	60430.			-78.	-4.90
34.0		14	491.	19.	475.			5.	34.21		1600.	82200.	1073.	61503.			-527.	-32.95
36.0		14	505.	19.	494.			5.	34.07		1800.	84000.	1198.	62700.			-602.	-33.46
38.0		13	518	19.	512			6.	44.23		2000.	86000.	1430.	64130.			-570.	-28.50
40.0		12.	530	39	551			27	224.17		2000.	88000.	6687.	70817.			4687.	234.33
42.0		13.	543	21.	573			8.	64.46		2000.	90000.	1188.	72005.			-812.	-40.62
44.0		12.	555	20	592.			8	62.58		2000.	92000.	972.	72977.			-1028.	-51.39
46.0		12	567.	19	611			7.	58.33		2000.	94000.	897.	73874.			-1103.	-55.15
48.0		12	579.	21.	632.			9	72.25		2000.	96000.	993.	74867.			-1007.	-50.33
50.0		11	590.	16.	648.			5	46.27		2000.	98000.	1282.	76150.			-718.	-35.89
52.0		13.	603	14.	661			1.	4.92		2000.	100000.	1437.	77587.			-563.	-28.14
54.0		13.	616	13	675			0.	3.38		2000.	102000.	1726.	79313.			-274.	-13.68
56.0		11	627	13	688			2.	19.91		1950.	103950.	2080.	81393.			130.	6.64
58.0		9.	636	14	702.			5	51.44		1900.	105850.	1983.	83376.			83.	4.39
60.0		9	645.	18	720.			9.	103.33		1900.	107750.	1119.	84495.			-781.	-41.11
62.0		20.	665.	18	738			-2.	-11.55		3300.	111050.	1135.	85630.			-2165.	-65.60
64.0		20	685.	19.	757			-1	-3.10		3300.	114350.	1159.	86789.			-2141.	-64.87
66.0		19.	704	15	773			-4	-18.95		3800.	118150.	1311.	88100.			-2489.	-65.51
68.0		18.	722	14.	787			-4.	-19.89		4300.	122450.	1348.	89448.			-2952.	-68.64
70.0		18	740	19.	806.			1	8.28		4300.	126750.	1823.	91271.			-2477.	-57.61
72.0		21.	761.	23	830			2.	11.00		2500.	129250.	2456.	93727.			-44.	-1.77
74.0		20	781.	25.	855			5.	25.35		2500.	131750.	3184.	96911.			684.	27.37
76.0		25	806	18	873			-7	-27.28		3200.	134950.	1820.	98731.			-1380.	-43.13
78.0		31.	837	38.	911			7	22.26		3900.	138850.	2793.	101524.			-1107.	-28.39
80.0		31.	868	26.	937			-5	-16.94		3900.	142750.	2530.	104054.			-1370.	-35.12
82.0		35	903	22.	959			-13.	-36.14		4100.	146850.	2181.	106236.			-1919.	-46.80
84.0		35	938	25	984			-10	-29.00		4100.	150950.	2452.	108688.			-1648.	-40.18
86.0		39	977	32	1016.			-6.	-16.67		3950.	154900.	3211.	111900.			-739.	-18.70
88.0		44	1021	33	1049			-11.	-24.66		3800.	158700.	2718.	114618.			-1082.	-28.47
90.0	970	44.	1065.			71.	1121.	27.	62.26	950	3800.	162500.			2885.	117503.	-915.	-24.08
95.0	962	140.	1205.			230.	1351.	90	64.01	940	10000.	172500.			7361.	124864.	-2639.	-26.39
100.0	953	195.	1400.			320	1671.	125.	64.16	930	10500.	183000.			7486.	132349.	-3014.	-28.71

SUMMARY	TO DATE		TO COMPLETION		TOTAL PROJECT	
	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)	DAYS	RANDS (000'S)
BUDGET	1021.0	158700.	379.0	24300.	1400.0	183000.
ACTUAL/FORECASTED	1049.5	114618.	621.1	17731.	1670.6	132349.
VARIANCE	28.5	-44082.	242.1	-6569.	270.6	-50651.
% VARIANCE	2.8	-28.	6.4	-27.	19.3	-28.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 45 SMOOTHING CONSTANTS: TIME= .459 COST= .061 D1T= 970 D2T= 00170 D1C= 950 D2C= 00200 G= 30

% COMP	U/T	TIME (DAYS) BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	COMMITMENTS (R000'S) BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64.	43.	43.			-21	-33.39		12400.	12400.	7970.	7970.			-4430	-35.73
4.0		64.	128.	41	83			-23	-36.25		12400	24800	7629	15599			-4771	-38.48
6.0		48.	176.	40	123.			-8.	-17.56		9800	34600	7399	22998.			-2400	-24.49
8.0		34.	210.	33.	156.			-1.	-1.65		7200	41800.	6253.	29251.			-947.	-13.15
10.0		33.	243.	33	189.			-0	-.82		7200	49000.	6118.	35370.			-1082.	-15.02
12.0		28.	271.	26.	215.			-2.	-7.75		4400.	53400	4830.	40200.			430.	9.78
14.0		27.	298.	25.	240.			-2	-5.74		4400	57800.	5854.	46054.			1454.	33.04
16.0		30.	328.	21.	261.			-9.	-31.50		4100	61900	1801.	47855.			-2299.	-56.07
18.0		32.	360.	24	285			-8.	-26.50		3800	65700.	2253.	50108.			-1547	-40.72
20.0		32.	392.	27.	311			-5	-15.69		3800.	69500.	2431.	52538.			-1369.	-36.03
22.0		11.	403.	24.	336.			13.	121.64		1400.	70900.	322.	52861.			-1078	-76.98
24.0		11.	414	19	355.			8.	70.45		1400.	72300	747.	53608.			-652.	-46.61
26.0		14.	428.	22.	376.			8.	55.50		1900.	74200	806.	54414.			-1094.	-57.59
28.0		17.	445.	26	403			9.	55.00		2400	76600	1514.	55928.			-885.	-36.90
30.0		17.	462.	29	432			12.	72.06		2400	79000.	2980.	58908.			580.	24.16
32.0		15.	477.	24.	456.			9.	60.00		1600.	80600.	1522.	60430.			-78.	-4.90
34.0		14.	491	19.	475			5	34.21		1600.	82200	1073.	61503.			-527.	-32.95
36.0		14.	505.	19.	494.			5	34.07		1800.	84000	1198	62700.			-602.	-33.46
38.0		13	518.	19.	512.			6.	44.23		2000.	86000	1430.	64130			-570	-28.50
40.0		12.	530.	39.	551			27	224.17		2000	88000.	6687.	70817			4687	234.33
42.0		13.	543.	21	573			8	64.46		2000	90000	1188.	72005			-812.	-40.62
44.0		12	555	20	592			8	62.58		2000	92000	972.	72977			-1028.	-51.39
46.0		12	567.	19	611.			7	58.33		2000	94000	897	73874.			-1103.	-55.15
48.0		12	579	21.	632.			9	72.25		2000	96000	993.	74867.			-1007	-50.33
50.0		11	590	16	648			5.	46.27		2000	98000.	1282.	76150.			-718.	-35.89
52.0		13.	603	14	661			1	4.92		2000	100000	1437	77587			-563.	-28.14
54.0		13.	616	13.	675			0	3.38		2000	102000	1726.	79313			-274.	-13.68
56.0		11	627.	13.	688.			2	19.91		1950	103950	2080.	81393			130.	6.64
58.0		9.	636.	14.	702.			5.	51.44		1900.	105850.	1983.	83376.			83.	4.39
60.0		9.	645.	18	720.			9	103.33		1900	107750	1119.	84495			-781	-41.11
62.0		20	665.	18	738			-2	-11.55		3300.	111050.	1135.	85630			-2165.	-65.60
64.0		20.	685.	19	757.			-1.	-3.10		3300.	114350	1159.	86789.			-2141.	-64.87
66.0		19.	704	15.	773.			-4.	-18.95		3800	118150	1311.	88100.			-2489.	-65.51
68.0		18.	722.	14.	787			-4.	-19.89		4300.	122450	1348.	89448			-2952.	-68.64
70.0		18.	740.	19.	806			1	8.28		4300	126750	1873	91271			-2477.	-57.61
72.0		21.	761.	23.	830.			2.	11.00		2500	129250	2456.	93727.			-44	-1.77
74.0		20.	781.	25.	855			5	25.35		2500	131750	3184.	96911			684.	27.37
76.0		25.	806.	18	873.			-7	-27.28		3200	134950	1820.	98731			-1380	-43.13
78.0		31	837.	38	911.			7	22.26		3900	138850	2793	101524			-1107	-28.39
80.0		31.	868.	26	937			-5.	-16.94		3900	142750	2530	104054			-1370.	-35.12
82.0		35.	903.	22.	959.			-13.	-36.14		4100	146850.	2181	106236			-1919.	-46.80
84.0		35	938.	25	984			-10	-29.00		4100	150950	2452.	108688			-1648	-40.18
86.0		39.	977	32.	1016			-6	-16.67		3950	154900	3211	111900			-739	-18.70
88.0		44.	1021.	33.	1049			-11.	-24.66		3800.	158700	2718.	114618			-1082	-28.47
90.0		43.	1064.	30	1080			-13.	-29.07		3800.	162500.	2449.	117067			-1350.	-35.54
95.0	970	140.	1204.			226	1306.	86	61.28	950	10000.	172500.			7303	124370	-2697	-26.97
100.0	962	195	1399.			313.	1619	118	60.66	940	10500	183000			7415	131785	-3085.	-29.38

SUMMARY

	TO DATE DAYS	TO DATE RANDS (000'S)	TO COMPLETION DAYS	TO COMPLETION RANDS (000'S)	TOTAL PROJECT DAYS	TOTAL PROJECT RANDS (000'S)
BUDGET	1064.0	162500	335.0	20500.	1399.0	183000.
ACTUAL/FORECASTED	1080.0	117067.	539.1	14718	1619.1	131785.
VARIANCE	16.0	-45433	204.1	-5782.	220.1	-51215
% VARIANCE	1.5	-28.	6.1	-28.	15.7	-28.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 46 SMOOTHING CONSTANTS: TIME= .687 COST= .062 D1T= 970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64.	43	43			-21	-33.39%		12400	12400	7970.	7970.			-4430.	-35.73%
4.0		64	128	41	83			-23.	-36.25%		12400.	24800	7629.	15599			-4771.	-38.48%
6.0		48.	176.	40.	123.			-8.	-17.56%		9800	34600	7399.	22998.			-2400.	-24.49%
8.0		34.	210	33	156			-1.	-1.65%		7200.	41800	6253.	29251.			-947.	-13.15%
10.0		33.	243	33	189			-0.	-.82%		7200	49000	6118.	35370			-1082.	-15.02%
12.0		28.	271	26	215			-2.	-7.75%		4400.	53400.	4830.	40200.			430.	9.78%
14.0		27	298.	25	240.			-2	-5.74%		4400.	57800	5854.	46054.			1454.	33.04%
16.0		30	328	21	261.			-9.	-31.50%		4100	61900.	1801.	47855.			-2299.	-56.07%
18.0		32.	360.	24.	285			-8.	-26.50%		3800	65700.	2253	50108.			-1547.	-40.72%
20.0		32	392.	27.	311.			-5	-15.69%		3800.	69500	2431	52538.			-1369.	-36.03%
22.0		11	403.	24.	336.			13.	121.64%		1400.	70900.	322.	52861.			-1078.	-76.98%
24.0		11.	414.	19.	355.			8.	70.45%		1400.	72300.	747.	53608.			-652.	-46.61%
26.0		14.	428.	22.	376.			8	55.50%		1900.	74200.	806.	54414			-1094.	-57.59%
28.0		17.	445.	26.	403.			9.	55.00%		2400	76600.	1514	55928.			-885.	-36.90%
30.0		17.	462	29.	432.			12.	72.06%		2400	79000	2980.	58908.			580.	24.16%
32.0		15.	477.	24.	456.			9.	60.00%		1600	80600.	1522.	60430			-78.	-4.90%
34.0		14.	491	19.	475			5	34.21%		1600	82200.	1073.	61503.			-527	-32.95%
36.0		14.	505.	19.	494			5	34.07%		1800	84000.	1198.	62700.			-602.	-33.46%
38.0		13	518.	19.	512.			6.	44.23%		2000	86000.	1430.	64130.			-570.	-28.50%
40.0		12.	530.	39.	551.			27.	224.17%		2000	88000.	6687.	70817			4687.	234.33%
42.0		13.	543	21.	573.			8.	64.46%		2000.	90000	1188.	72005			-812	-40.62%
44.0		12.	555.	20.	592.			8.	62.58%		2000.	92000	972.	72977			-1028.	-51.39%
46.0		12.	567.	19.	611.			7.	58.33%		2000.	94000.	897.	73874.			-1103.	-55.15%
48.0		12.	579.	21	632.			9	72.25%		2000	96000.	993.	74867			-1007.	-50.33%
50.0		11.	590.	16.	648			5	46.27%		2000.	98000.	1282.	76150.			-718.	-35.89%
52.0		13.	603	14.	661.			1.	4.92%		2000	100000.	1437	77587			-563.	-28.14%
54.0		13.	616	13.	675.			0.	3.38%		2000	102000	1726.	79313.			-274.	-13.68%
56.0		11	627.	13.	688			2	19.91%		1950.	103950.	2080.	81393.			130.	6.64%
58.0		9	636	14	702.			5	51.44%		1900.	105850	1983.	83376.			83.	4.39%
60.0		9.	645	18	720.			9.	103.33%		1900	107750	1119.	84495.			-781.	-41.11%
62.0		20.	665.	18	738.			-2.	-11.55%		3300	111050.	1135.	85630			-2165.	-65.60%
64.0		20.	685.	19.	757			-1	-3.10%		3300	114350.	1159	86789.			-2141.	-64.87%
66.0		19	704	15	773.			-4	-18.95%		3800	118150	1311	88100			-2489.	-65.51%
68.0		18.	722	14	787			-4	-19.89%		4300	122450	1348	89448			-2952.	-68.64%
70.0		18.	740	19.	806			1	8.28%		4300	126750.	1823.	91271.			-2477.	-57.61%
72.0		21	761	23	830			2	11.00%		2500	129250.	2456	93727			-44.	-1.77%
74.0		20.	781	25.	855			5	25.35%		2500	131750.	3184.	96911			684	27.37%
76.0		25	806	18	873			-7	-27.28%		3000	134750	1820	98731			-1380.	-43.13%
78.0		31.	837	38.	911			7.	22.26%		3900	138850.	2793.	101524			-1107.	-28.39%
80.0		31	868.	26	937			-5	-16.94%		3900	142750.	2530	104054			-1370.	-35.12%
82.0		35	903	22.	959			-13.	-36.14%		4100	146850	2181.	106236			-1919	-46.80%
84.0		35	938	25	984.			-10	-29.00%		4100	150950.	2452	108688			-1648	-40.18%
86.0		39	977	32.	1016.			-6.	-16.67%		3950	154900.	3211.	111900.			-739.	-18.70%
88.0		44	1021.	33	1049			-11	-24.66%		3800	158700	2718	114618			-1082.	-28.47%
90.0		43	1064	30	1080			-13.	-29.07%		3800	162500	2449	117067			-1350.	-35.54%
92.0		57	1121.	30.	1110.			-26	-46.49%		4000	166500	2460	119527.			-1540.	-38.50%
95.0	.970	84.	1205.			133	1243.	49.	58.24%	.950	6000	172500			4347.	123875.	-1653.	-27.55%
100.0	.962	195.	1400			306	1549.	111.	56.77%	.940	10500.	183000			7345	131219.	-3155	-30.05%

SUMMARY

	TO DATE DAYS	TO DATE RANDS (000'S)	TO COMPLETION DAYS	TO COMPLETION RANDS (000'S)	TOTAL PROJECT DAYS	TOTAL PROJECT RANDS (000'S)
BUDGET	1121.0	166500.	279.0	16500	1400.0	183000.
ACTUAL/FORECASTED	1110.5	119527.	438.6	11692.	1549.1	131219.
VARIANCE	-10.5	-46973.	159.6	-4808.	149.1	-51781.
% VARIANCE	-.9	-28.	5.7	-29	10.7	-28.

REPORT NUMBER 47 SMOOTHING CONSTANTS: TIME= .104 COST= .564 D1T= 970 D2T= 00170 D1C= 950 D2C= .00200 G= .30

% COMP	U/T	TIME (DAYS) BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	COMMITMENTS (R000'S) BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64.	43.	43.			-21.	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128.	41	83.			-23.	-36.25		12400.	24800.	7629.	15599.			-4771.	-38.48
6.0		48.	176.	40.	123.			-8.	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34.	210.	33.	156.			-1.	-1.65		7200.	41800.	6253.	29251.			-947.	-13.15
10.0		33.	243.	33	189.			-0	-.82		7200.	49000.	6118.	35370.			-1082.	-15.02
12.0		28.	271.	26	215.			-2.	-7.75		4400.	53400	4830.	40200.			430.	9.78
14.0		27.	298.	25.	240.			-2.	-5.74		4400.	57800.	5854.	46054.			1454.	33.04
16.0		30.	328	21.	261.			-9.	-31.50		4100.	61900.	1801.	47855.			-2299.	-56.07
18.0		32.	360.	24.	285.			-8.	-26.50		3800.	65700.	2253.	50108.			-1547.	-40.72
20.0		32	392.	27.	311.			-5.	-15.69		3800.	69500	2431.	52538.			-1369.	-36.03
22.0		11.	403	24.	336.			13.	121.64		1400	70900.	322.	52861			-1078.	-76.98
24.0		11.	414.	19.	355.			8	70.45		1400	72300.	747.	53608.			-652.	-46.61
26.0		14.	428	22.	376			8	55.50		1900	74200	806.	54414.			-1094.	-57.59
28.0		17	445	26.	403.			9.	55.00		2400	76600	1514.	55928.			-885	-36.90
30.0		17.	462.	29.	432.			12.	72.06		2400	79000.	2980.	58908			580	24.16
32.0		15.	477	24.	456			9	60.00		1600	80600.	1522.	60430.			-78.	-4.90
34.0		14.	491	19.	475.			5	34.21		1600	82200	1073.	61503.			-527	-32.95
36.0		14.	505.	19.	494			5	34.07		1800	84000.	1198	62700.			-602.	-33.46
38.0		13.	518	19.	512			6	44.23		2000	86000.	1430	64130			-570.	-28.50
40.0		12.	530	39.	551			27	224.17		2000	88000.	6687	70817.			4687.	234.33
42.0		13.	543.	21.	573.			8	64.46		2000	90000.	1188.	72005.			-812.	-40.62
44.0		12.	555.	20	592			8.	62.58		2000	92000	972.	72977			-1028.	-51.39
46.0		12.	567	19	611			7	58.33		2000	94000	897	73874			-1103.	-55.15
48.0		12	579	21	632.			9	72.25		2000	96000.	993.	74867			-1007.	-50.33
50.0		11.	590	16	648			5	46.27		2000	98000	1282.	76150			-718.	-35.89
52.0		13	603.	14	661			1	4.92		2000	100000	1437	77587			-563.	-28.14
54.0		13	616	13	675			0	3.38		2000	102000	1726	79313			-274.	-13.68
56.0		11	627.	13.	688			2.	19.91		1950.	103950.	2080.	81393.			130.	6.64
58.0		9	636	14	702			5	51.44		1900	105850	1983	83376			83.	4.39
60.0		9	645	18	720			9	103.33		1900	107750	1119	84495			-781.	-41.11
62.0		20	665	18	738			-2	-11.55		3300	111050	1135.	85630			-2165.	-65.60
64.0		20	685	19.	757			-1.	-3.10		3300.	114350.	1159.	86789			-2141.	-64.87
66.0		19	704.	15.	773.			-4.	-18.95		3800.	118150	1311.	88100.			-2489.	-65.51
68.0		18	722.	14	787			-4	-19.89		4300	122450	1348.	89448			-2952.	-68.64
70.0		18	740	19	806.			1.	8.28		4300.	126750.	1823.	91271.			-2477.	-57.61
72.0		21.	761	23.	830			2.	11.00		2500.	129250	2456.	93727.			-44.	-1.77
74.0		20.	781.	25.	855.			5.	25.35		2500.	131750	3184.	96911.			684.	27.37
76.0		25	806	18.	873.			-7	-27.28		3200	134950	1820.	98731.			-1380.	-43.13
78.0		31.	837.	38.	911			7.	22.26		3900.	138850	2793.	101524.			-1107.	-28.39
80.0		31.	868.	26.	937.			-5.	-16.94		3900.	142750	2530.	104054.			-1370.	-35.12
82.0		35	903.	22.	959			-13.	-36.14		4100	146850.	2181.	106236.			-1919.	-46.80
84.0		35	938.	25	984			-10	-29.00		4100.	150950.	2452.	108688			-1648.	-40.18
86.0		39	977	32	1016			-6	-16.67		3950	154900.	3211.	111900.			-739.	-18.70
88.0		44	1021	33	1049			-11.	-24.66		3800	158700	2718.	114618.			-1082.	-28.47
90.0		43	1064	30.	1080.			-13.	-29.07		3800.	162500.	2449	117067			-1350.	-35.54
92.0		57	1121	30	1110			-26.	-46.49		4000.	166500	2460.	119527			-1540.	-38.50
94.0		56	1177	41.	1152			-15	-26.20		4000	170500	3682.	123210			-317.	-7.94
95.0	.970	28.	1205.			43.	1195.	15	55.31	950	2000	172500.			1455.	124665	-545.	-27.24
100.0	.962	195.	1400			298.	1494.	103.	53.04	940	10500	183000			7381	132046.	-3119.	-29.70

SUMMARY	TO DATE DAYS	TO DATE RANDS (000'S)	TO COMPLETION DAYS	TO COMPLETION RANDS (000'S)	TOTAL PROJECT DAYS	TOTAL PROJECT RANDS (000'S)
BUDGET	1177 0	170500.	223. 0	12500	1400. 0	183000.
ACTUAL/FORECASTED	1151 8	123210	341. 9	8837.	1493. 7	132046.
VARIANCE	-25 2	-47290.	118. 9	-3663.	93. 7	-50954.
% VARIANCE	-2 1	-28	5. 3	-29	6. 7	-28.

GENERALISED RESOURCE APPRAISEMENT MODEL

REPORT NUMBER 48 SMOOTHING CONSTANTS: TIME= .783 COST= .948 D1T=.970 D2T=.00170 D1C=.950 D2C=.00200 G=.30

	TIME (DAYS)									COMMITMENTS (R000'S)								
% COMP	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2.0		64.	64.	43.	43.			-21.	-33.39		12400.	12400.	7970.	7970.			-4430.	-35.73
4.0		64.	128	41.	83			-23.	-36.25		12400	24800.	7629.	15599.			-4771.	-38.48
6.0		48.	176.	40	123.			-8.	-17.56		9800.	34600.	7399.	22998.			-2400.	-24.49
8.0		34	210	33	156.			-1.	-1.65		7200.	41800	6253.	29251.			-947.	-13.15
10.0		33	243.	33	189			-0.	-.82		7200.	49000	6118.	35370.			-1082.	-15.02
12.0		28	271.	26	215			-2	-7.75		4400	53400	4830	40200.			430	9.78
14.0		27	298.	25	240.			-2	-5.74		4400.	57800	5854.	46054.			1454.	33.04
16.0		30.	328	21.	261.			-9	-31.50		4100.	61900.	1801.	47855.			-2299.	-56.07
18.0		32	360	24	285			-8	-26.50		3900	65700	2253.	50108			-1547.	-40.72
20.0		32	392	27	311			-5	-15.69		3800	69500	2431.	52538			-1369.	-36.03
22.0		11.	403	24	336			13	121.64		1400	70900	322	52861			-1078	-76.98
24.0		11	414	19.	355.			8	70.45		1400	72300.	747.	53608.			-652.	-46.61
26.0		14.	428	22.	376.			8	55.50		1900.	74200.	806.	54414.			-1094.	-57.59
28.0		17.	445	26.	403			9	55.00		2400	76600.	1514	55928.			-885.	-36.90
30.0		17	462.	29.	432.			12.	72.06		2400	79000.	2980.	58908.			580.	24.16
32.0		15.	477	24.	456.			9.	60.00		1600	80600.	1522.	60430			-78.	-4.90
34.0		14	491.	19	475.			5.	34.21		1600	82200.	1073.	61503.			-527.	-32.95
36.0		14	505.	19	494			5.	34.07		1800	84000.	1198.	62700.			-602.	-33.46
38.0		13.	518.	19.	512.			6.	44.23		2000.	86000.	1430.	64130.			-570.	-28.50
40.0		12.	530.	39.	551.			27.	224.17		2000.	88000.	6687.	70817.			4687.	234.33
42.0		13.	543.	21.	573.			8.	64.46		2000.	90000.	1188.	72005.			-812.	-40.62
44.0		12.	555.	20.	592.			8.	62.58		2000.	92000.	972.	72977			-1028.	-51.39
46.0		12.	567.	19	611.			7	58.33		2000.	94000	897.	73874.			-1103	-55.15
48.0		12.	579.	21.	632.			9.	72.25		2000	96000.	993.	74867.			-1007	-50.33
50.0		11.	590.	16.	648.			5.	46.27		2000	98000.	1282.	76150			-718.	-35.89
52.0		13.	603.	14	661.			1.	4.92		2000	100000.	1437.	77587.			-563.	-28.14
54.0		13.	616.	13.	675			0.	3.38		2000	102000.	1726.	79313.			-274.	-13.68
56.0		11.	627	13.	688			2.	19.91		1950	103950.	2080.	81393.			130.	6.64
58.0		9.	636	14.	702.			5	51.44		1900.	105850.	1983.	83376.			83.	4.39
60.0		9	645	18	720.			9	103.33		1900	107750.	1119	84495			-781	-41.11
62.0		20.	665.	18	738			-2	-11.55		3300	111050.	1135	85630			-2165.	-65.60
64.0		20	685	19	757			-1	-3.10		3300	114350	1159	86789			-2141.	-64.87
66.0		19.	704	15	773.			-4	-18.95		3800	118150	1311.	88100			-2489.	-65.51
68.0		18	722	14	787			-4	-19.89		4000	122450	1048	89440			-2952	-68.64
70.0		10	740	19	806			1	8.28		4000	126750	1823	91271			-2477	-57.61
72.0		21	761	23	830			2	11.00		2500.	129250	2456	93727			-44.	-1.77
74.0		20.	781.	25.	855			5.	25.35		2500	131750.	3184	96911			684.	27.37
76.0		25.	806	18	873			-7.	-27.28		3000	134950	1820	98731			-1380.	-43.13
78.0		31	837	38	911			7	22.26		3900	138850	2793	101524			-1107.	-28.39
80.0		31.	868	26.	937			-5	-16.94		3900	142750	2530	104054			-1370.	-35.12
82.0		35.	903	22	959.			-13	-36.14		4100	146850	2181.	106236			-1919	-46.80
84.0		35	938	25	984			-10	-29.00		4100	150950	2452	108688			-1648	-40.18
86.0		39	977	32	1016			-6	-16.67		3950	154900	3211	111900			-739	-18.70
88.0		44.	1021.	33	1049			-11	-24.66		3800	158700.	2718	114618			-1082.	-28.47
90.0		43.	1064	30	1080			-13	-29.07		3800	162500.	2449	117067			-1350.	-35.54
92.0		57.	1121.	30	1110			-26	-46.49		4000	166500.	2460	119527			-1540.	-38.50
94.0		56	1177	41	1152.			-15	-26.20		4000	170500	3682.	123210			-317.	-7.94
95.0		28	1205	51.	1202.			23	80.96		2000	172500.	7035	130245.			5035.	251.77
100.0	.970	195.	1400			298.	1501	103	53.01	950	10500	183000			8725	138970	-1775.	-16.91

SUMMARY

	TO DATE DAYS	TO DATE RANDS (000'S)	TO COMPLETION DAYS	TO COMPLETION RANDS (000'S)	TOTAL PROJECT DAYS	TOTAL PROJECT RANDS (000'S)
BUDGET	1205 0	172500	195 0	10500	1400 0	183000.
ACTUAL/FORECASTED	1202 5	130245	298 4	8725.	1500 9	138970.
VARIANCE	-2.5	-42255	103 4	-1775.	100 9	-44030.
% VARIANCE	- 2	-24	5.3	-17.	7 2	-24.

REPORT NUMBER 49 SMOOTHING CONSTANTS TIME= 944 COST= 0.0 U1I= 970 U2I=.00170 U1C= 950 U2C= .00200 G= 30

TIME (DAYS)										COMMITMENTS (R000'S)									
% COMP	%	U/T	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR	U/C	BUDGET PROG	BUDGET CUM	ACTUAL PROG	ACTUAL CUM	FORECAST PROG	FORECAST CUM	PROGRESSIVE VAR	PROGRESSIVE %VAR
2	0		64	64	43	43			-21	-33 39		12400	12400	7970	7970			-4430	-35 73
4	0		64	128	41	83			-23	-36 [illegible]		1,400	24800	7629	15599			4771	-38 40
6	0		48	176	40	123			0	-17 [illegible]		[illegible]	34600	7399	22998			-2400	-24 49
8	0		34	210	33	156			-1	-1 65		[illegible]	41800	6253	29251			-947	-13 15
10	0		33	243	33	189			-0	[illegible]		[illegible]	49000	6118	35370			-1082	-15 02
12	0		28	271	26	215			2	7 [illegible]		4400	53400	4120	40200			430	9 78
14	0		27	298	25	240			-2	-1 [illegible]		4400	57800	5854	46054			1454	33 04
16	0		30	328	21	261			9	-31 50		4100	61900	1801	47855			-2299	-56 07
18	0		32	360	24	285			8	-25 00		[illegible]	65700	2253	50108			-1547	40 72
20	0		32	392	27	311			5	15 62		[illegible]	69200	2461	52569			-1367	-26 03
22	0		11	403	24	335			13	101 64		1400	70600	622	53191			-1078	-76 98
24	0		11	414	19	355			8	70 45		1400	72000	747	53938			-692	-48 61
26	0		14	428	22	376			8	55 50		1930	73930	806	54744			-1094	-57 59
28	0		17	445	24	400			9	55 00		[illegible]	75430	1514	56258			-885	-36 90
30	0		17	462	29	432			12	72 06		[illegible]	78430	2990	59248			580	24 16
32	0		15	477	24	456			9	60 00		[illegible]	80430	1672	60430			-78	-4 90
34	0		14	491	19	475			-5	-34 21		[illegible]	82130	1077	61507			-527	-32 95
36	0		14	505	19	494			-5	-34 07		[illegible]	83830	1173	62680			-702	-33 46
38	0		13	518	19	513			-6	-44 [illegible]		[illegible]	85530	1150	63830			-570	-28 50
40	0		12	530	39	551			22	224 17		2000	87000	6687	70817			4687	234 33
42	0		13	543	21	573			-8	-44 44		2000	89000	1188	72005			-812	-40 62
44	0		12	555	20	592			-8	-47 50		2000	91000	972	72977			1028	-51 39
46	0		12	567	19	611			-7	-58 33		2000	93000	897	73874			-1103	-55 15
48	0		12	579	21	632			-9	-75 25		2000	95000	973	74847			-1007	-50 33
50	0		11	590	16	648			-5	-46 27		2000	97000	1303	76150			-718	-35 89
52	0		13	603	14	661			1	4 92		2000	99000	1437	77587			-563	-28 14
54	0		13	616	13	675			0	3 38		2000	101000	1726	79313			-274	-13 68
56	0		11	627	13	688			2	19 91		1950	102950	2080	81393			130	6 64
58	0		9	636	14	702			5	51 44		1700	104650	1983	83376			83	4 39
60	0		9	645	18	720			9	101 11		1900	106550	1119	84495			201	-41 11
62	0		20	665	18	738			-2	-11 00		3300	110050	1135	85630			-2165	-65 60
64	0		20	685	19	757			-1	-3 10		3300	113350	1159	86789			-2141	-64 87
66	0		19	704	15	773			-4	-18 95		3000	116350	1311	88100			-2489	-65 51
68	0		18	722	14	787			4	19 00		4100	120450	1148	89248			-2952	-68 64
70	0		18	740	19	806			1	8 20		4300	124750	1823	91071			-2477	-57 61
72	0		21	761	23	830			2	11 00		2500	127250	2456	93727			-44	-1 77
74	0		20	781	25	855			5	25 35		2500	129750	3184	96911			684	27 37
76	0		25	806	18	873			-7	-27 78		[illegible]	134950	1060	98731			-1380	-43 13
78	0		31	837	38	911			7	22 26		[illegible]	140850	2793	101524			-1107	-28 39
80	0		31	868	26	937			-5	-16 94		3900	142750	2530	104054			-1370	-35 12
82	0		35	903	22	959			-13	-36 14		4100	146850	2181	106236			-1919	-46 80
84	0		35	938	26	984			-10	-29 00		4100	150950	2452	108688			-1648	-40 18
86	0		39	977	32	1016			-6	-16 67		[illegible]	154900	3011	111700			-739	-18 70
88	0		44	1021	33	1049			-11	-24 [illegible]		[illegible]	158700	2718	114418			-1082	-28 47
90	0		43	1064	30	1080			-13	-29 07		[illegible]	162500	2449	117867			-1350	-35 54
92	0		57	1121	30	1110			-26	46 42		[illegible]	166500	2440	119307			-1540	-38 50
94	0		56	1177	41	1152			-15	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]			317	-7 94
95	0		28	1205	51	1202			23	82 14		[illegible]	[illegible]	[illegible]	[illegible]			5035	251 77
96	0		39	1244	25	1227			36	93 59		[illegible]	[illegible]	[illegible]	[illegible]			5666	269 03
100	0	970	156	1400			140	1518	84	58 34	950	[illegible]	183000			0125	146207	205	-2 44

SUMMARY

	TO DATE DAYS	TO DATE RANDS (000'S)	TO COMPLETION DAYS	TO COMPLETION RANDS (000'S)	TOTAL PROJECT DAYS	TOTAL PROJECT RANDS (000'S)
BUDGET	1244 0	174600	156 0	[illegible]400	1400 0	183000
ACTUAL/FORECASTED	1229 0	139017	140 3	6125	1518 3	146207
VARIANCE	14 0	26108	14 3	1205	118 3	36793
% VARIANCE	2 7	-21	5 4	-2	8 4	-20.

APPENDIX K

SUMMARY OF THE RESULTS OF THE OBJECTIVE COMPUTER RUN

TABLE: K-1: SUMMARY OF APPENDIX J

g = 0,30; Di_e = 0.9501; Olt 0,970; D2t = 0,0017; D2c = 0,0020

PPC	TOTAL TIME (DAYS)	TOTAL COMMITMENTS (R 000,s)
2	1 323	170 034
4	1 246	157 33
6	1 189	148 607
8	1 175	144 357
10	1 172	141 805
12	1 172	144 700
14	1 170	152 620
16	1 153	152 470
18	1 134	149 268
20	1 120	145 056
22	1 233	136 355
24	1 340	129 938
26	1 448	124 204
28	1 557	119 404
30	1 663	121 935
32	1 760	123 852
34	1 812	124 881
36	1 852	125 497
38	1 894	125 787
40	2 056	148 004
40	2 056	148 004
42	2 210	166 396
44	2 335	175 261
46	2 410	174 398
48	2 473	169 855
50	2 488	165 898
52	2 450	162 606
54	2 400	160 469

Table K-1 continued

PPC	TOTAL TIME (DAYS)	TOTAL COMMITMENTS (R 000,s)
56	2 365	159 398
58	2 337	158 380
60	2 337	156 422
62	2 309	151 982
64	2 271	147 054
66	2 216	142 199
68	2 154	137 140
70	2 108	133 332
72	2 065	133 306
74	2 027	135 682
76	1 975	135 820
78	1 935	135 474
80	1 889	135 474
82	1 829	134 014
84	1 774	132 807
86	1 724	132 716
88	1 671	132 349
90	1 619	131 785
92	1 549	131 219
94	1 494	132 046
95	1 501	138 970
96	1 518	146 207

The table indicate the total project duration and cost as forecasted at certain values of PPC. Obtained from Appendix J.

TABLE: K-2: PROGRESSIVE PERCENTAGE VARIANCES AS OBTAINED FROM APPENDIX J

PPC	% VARIANCE (PROGRESSIVE)	
	TIME	COMMITMENTS
2	- 33,4	- 35,7
4	- 36,3	- 38,5
6	- 17,6	- 24,5
8	- 1,7	- 13,2
10	- 0,8	- 15,0
12	- 7,8	9,8
14	- 5,7	33,0
16	- 31,5	- 56,1
18	- 26,5	- 40,7
20	- 15,7	- 36,0
22	121,6	- 77,0
24	70,5	- 46,6
26	55,5	- 35,9
28	55,0	- 36,6
30	72,1	24,2
32	60,0	- 4,9
34	34,2	- 33,0
36	34,1	- 33,5
38	44,2	- 28,5
40	224,2	234,3
42	64,5	- 40,6
44	62,6	- 51,4
46	58,3	- 55,2
48	72,3	- 50,3
50	46,3	- 35,9
52	4,9	- 28,1
54	3,4	- 13,7
56	19,9	6,6
58	51,4	4,4
60	103,3	- 41,1

Table K-2 continued

PPC	% VARIANCE (PROGRESSIVE)	
	TIME	COMMITMENTS
62	- 11,6	- 65,6
64	- 3,1	- 64,9
66	- 19,0	- 65,5
68	- 20,0	- 68,6
70	8,3	- 57,6
72	11,0	- 1,8
74	25,4	27,4
76	- 27,3	- 43,1
78	22,3	- 28,4
80	- 17,0	- 35,1
82	- 36,1	- 46,8
84	- 29,0	- 40,2
86	- 16,7	- 18,7
88	- 24,7	- 28,5
90	- 29,1	- 35,5
92	- 46,5	- 38,5
94	- 26,2	- 7,9
95	81,0	251,8
96	93,6	269,8

NOTE: A Negative variance is favourable i.e. it is below budget whilst a positive variance is unfavourable i.e. it is above budget.

TABLE: K-3: CUMULATIVE BUDGET VARIANCES CALCULATED FROM APPENDIX J

PPC	CUMULATIVE % BUDGET VARIANCE	
	TIME	COMMITMENTS
2	- 33,4	- 35,7
4	- 54,2	- 59,0
6	- 43,1	- 50,4
8	- 34,6	- 42,9
10	- 28,6	- 38,5
12	- 26,0	- 32,8
14	- 24,2	- 25,5
16	- 25,7	- 29,3
18	- 26,3	- 31,1
20	- 26,0	- 32,3
2?	- 19,9	- 34,1
24	- 16,6	- 34,9
26	- 13,8	- 36,4
28	- 10,4	- 37,0
30	- 6,9	- 34,1
32	- 4,6	- 33,4
34	- 3,4	- 33,7
36	- 2,2	- 34,0
38	- 1,2	- 34,1
40	3,8	- 24,3
42	5,2	- 25,0
44	6,3	- 26,1
46	7,3	- 27,2
48	8,4	- 28,2
50	9,0	- 28,7
52	8,8	- 28,9
54	8,7	- 28,6
56	8,9	- 27,7
53	9,4	- 27,0
60	10,4	- 27,5

Table K-3 continued

PPC	CUMULATIVE % BUDGET VARIANCE	
	TIME	COMMITMENTS
62	9,9	- 29,7
64	9,5	- 31,8
66	8,9	- 34,1
68	8,3	- 36,9
70	8,2	- 38,9
72	8,3	- 37,9
74	8,7	- 35,9
76	7,7	- 36,7
78	8,1	- 36,3
80	7,4	- 37,2
82	5,8	- 38,2
84	4,7	- 38,9
86	3,8	- 33,9
88	2,7	- 38,5
90	1,5	- 38,8
92	- 1,0	- 39,3
94	- 2,2	- 38,4
95	- 2,0	- 82,4
96	2,7	- 26,5

SAMPLE CALCULATION: At 40 PPC, the commitments budgeted were R88 million. The reported commitments wer R70 817 million.

Hence the % variance is (88/70 817) x 100 = 24,37

TABLE: K-4A: FORECASTED VARIANCES FOR COMMITMENTS

(For ease of calculation these were calculated at 10 PPC intervals)

PPC	CUMULATIVE COMMITMENTS REPORTED AT PPC	CUMULATIVE COMMITMENTS FORECASTED AT PPC-10	CUMULATIVE % VARIANCE	PROGRESSIVE COMMITMENTS REPORTED AT PPC	PROGRESSIVE COMMITMENTS FORECASTED AT PPC-10	PROGRESSIVE % VARIANCE
10	35 370	49 000	- 38,5	35 370	49 000	38,5
20	52 538	53 913	- 2,6	17 168	4 913	71,4
30	58 908	61 100	- 3,7	6 370	7 187	- 12,8
40	70 817	65 771	7,1	11 909	4 671	60,8
50	76 150	79 305	- 4,1	5 333	13 534	-153,8
60	84 495	85 933	4,0	8 345	1 827	- 78,1
70	91 271	102 715	- 12,5	6 776	21 583	-218,5
80	104 054	104 014	00,0	12 783	1 299	89,8
90	117 067	119 847	- 2,4	13 013	15 833	- 21,7
96	138 012	125 853*	8,8	20 945	6 006	71,3

* This figure obtained by interpolation of figures forecasted in report 45.

SAMPLE CALCULATION.: Refer to Report numbers 20 and 25 in Appendix J. When the project was 40 PPC, the cumulative forecasted commitments at 50 PPC were R79,305 million. When the project was 50 PPC, the reported commitments were R76,15 million. Hence, the cumulative % forecasted variance at 50 PPC is :

$$(I - \frac{79305}{76150}) \times 100 = -4,1\%$$

i.e. the reported commitments were 4,1% below what had been forecasted in the previous period.

TABLE: K-4B: FORECASTED VARIANCES FOR TIME

(For ease of calculation these were calculated at 10 PPC intervals)

PPC	CUMULATIVE DURATION REPORTED AT PPC	CUMULATIVE DURATION FORECASTED AT PPC-10	CUMULATIVE % VARIANCE	PROGRESSIVE DURATION REPORTED AT PPC	PROGRESSIVE DURATION FORECASTED AT PPC-10	PROGRESSIVE % VARIANCE
10	243	189	22,2	243	189	22,2
20	311	329	- 5,8	68	140	-105,9
30	432	376	13,0	121	47	61,2
40	551	506	8,2	119	130	- 9,2
50	648	627	3,2	97	121	- 24,7
60	720	734	- 1,9	72	107	- 48,6
70	806	882	- 9,4	86	143	- 72,1
80	937	1 034	4,3	131	152	- 16,0
90	1 080	1 279	- 18,4	143	2-5	- 71,3
96	1 278	1 369*	- 7,1	198	90	54,5

This figure was calculated by interpolating the figures forecasted in report 95.

The calculations are identical to those for Table K-4A.

FIGURE K-1

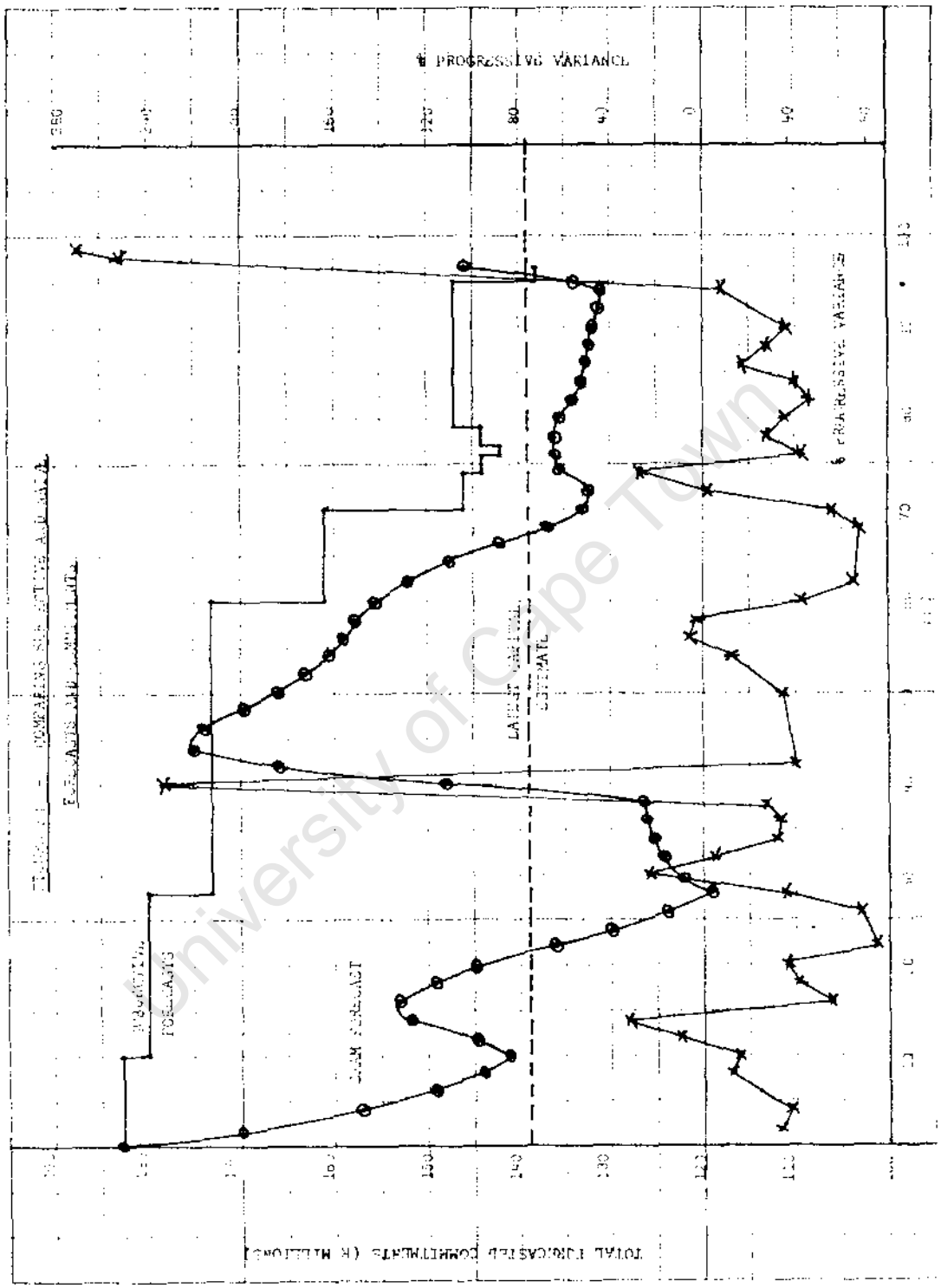


FIGURE K-2